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HYDRAULIC MINING IN CALIFORNIA has received a serious set-back by a decision of Judge Ross of the United States Circuit Court, in San Francisco, on June 8, enjoining the North Bloomfield Mining Co., which operates one of the largest hydraulic gold mining operations in the state, from discharging its debris into the Sacramento River. The decision sustains the constitutionality of the Caminetti law, which was recently passed by Congress to regulate hydraulic mining. It was alleged by the government that the company had not erected competent impounding works and the works, such as they were, had not been officially sanctioned by the Debris Commission. In answer to the government's complaint the Bloomfield Company alleged that its impounding works were such as the law required. It was admitted that the restraining dams had not been formally permitted by the Debris Commission.

Justice Ross, reviewing the law at length, said:

> Its real intent and meaning is to prohibit and make unlawful any and all hydraulic mining in the territory drained by the Sacramento and San Joaquin river systems in the state of California, or indirectly involving the navigability of said river systems and to permit it in all cases where the work can be prosecuted without such injury to the navigability of the said river systems, or to the lands adjacent thereto. * * * Congress has created a commission under the direction of the Secretary of War and under the supervision of the Chief of Engineers of the army to ascertain and determine whether the various hydraulic mines within the territory drained by the Sacramento and San Joaquin river systems can be operated by means of impounding reservoirs and other works without injury to those navigable waters; and, if so, the act of Congress permitting them to be operated in such prescribed way as will prevent any such injury. Until the matters of fact committed to the commission have been ascertained and the extent and methods of the work so prescribed by the act of Congress of any mine by the hydraulic process, within the territory drained by the Sacramento and San Joaquin river systems from which any debris matter flows into these waters.

MINING OF COAL BY HYDRAULIC PRESSURE—the subject of a paper read at a meeting of the Manchester, Eng., Geological Society, by Mr. James Tonge, F. C. S. He showed an apparatus called a hydraulic cartridge, 18 ins. long and 3 ins. diameter, made of steel, and a small but powerful hand pump. In mining the coal is undercut to the usual depth and a hole is drilled near the roof as if for blasting. In this hole the hydraulic cartridge is placed, connected by a small pipe with the pump, and the swelling of the cartridge by the pressure applied starts a crack in the coal, dislodging it without shock, without shattering it as is done by blasting, and without danger of igniting combustible gases or dust. If the new system of breaking down coal by hydraulic pressure should prove successful in practice it would greatly decrease the dangers of coal mining.

THE GEOLOGICAL AND ECONOMIC SURVEY OF Maryland ordered by the Legislature in 1896 is reported upon by State Geologist Wm. Bullock Clark. A preliminary survey of the State has been commenced to obtain general information in regard to all mines, pits and quarries, and special investigations have been started of all building and decorative stones. An important work of the State Geologist under this act is the establishment of a magnetic survey. At the date of the report stations had been established at every county seat in Maryland and at other points, and many of the early stations of the U. S. Coast and Geodetic Survey, near Chesapeake Bay, had been reoccupied. The data thus furnished are of immediate value to land surveyors. Topographical maps are also being prepared in co-operation with the U. S. Geological Survey, and this survey now covers several hundred square miles in the northern and northeastern section of the State. Two reports are being prepared on the geology and on the stone-quarrying industry of the State. The commission in charge of this survey includes the Governor of the State, the Comptroller, the President of Johns Hopkins University and the President of the Maryland Agricultural College.

A GEOLOGICAL AND ECONOMIC SURVEY of West Virginia is ordered by House Bill No. 96, passed at the last session of the Legislature. It is similar to the act passed in 1896 by the Maryland Legislature. It places the survey under a commission made up of the Governor, Treasurer, President of the West Virginia University, President of the State Board of Agriculture and the Director of the West Virginia Agricultural Experiment Station, who serve without compensation, except actual expenses. They appoint as superintendent of the survey a geologist of reputation, and such assistants as they deem necessary. The objects of the survey are: an examination of the geological formation of the State, with special reference to its economic products; an examination of the soils and the adaptability to particular crops; an examination of forests; a study of the physical features of the State with reference to their practical bearing upon occupations, industrial development and material prosperity of the people; the preparation of special geological and economic maps to illustrate the resources of the State, and the preparation of special reports on geology and State resources.

THE CEMENT MATERIALS of Southwest Arkansas are reported upon by Mr. John C. Branner in the "Transactions of the American Institute of Mining Engineers." These are chalk and clay beds. Analyses of the chalk deposits show many samples high in lime and low in deleterious ingredients, with an average of magnesia below 2%. The surface clays near the chalk deposits are not uniform in composition, but the Tertiary rocks contain an abundance of clay available for cement making and some of the beds are now being utilized in the manufacture of pottery. The paper describes each known deposit, and gives analyses of the chalks and clays.

THE STEEL LEVEE CORE referred to in our issue of May 20, is accompanied by a provision against oxidation. According to a letter received from the inventor, Mr. M. H. King, of Des Moines, Ia., the metal is to be coated with asphalt or other preservative compound. A metal plate is also bolted to the cap of the piles to prevent burrowing by animals or scour by water; this plate is riveted to an angle-iron spiked to the cap. The plan also provides for the covering of the top of the levee by a concrete cap to prevent washing from rain. The purpose of Mr. King's invention is to keep the land side of the levee always dry by preventing seepage and also to prevent the perforation of the levee by burrowing animals.

THE CAST-STEEL STERN FRAME of the White Star steamer "Oceanic," now under construction by Harland & Wolff, of Belfast, Ireland, is in one piece and weighed 41 tons in the rough and 35 tons after being completely machined ready for erection. This casting is 35 ft. high by 24 ft. 3 in. over the keel-piece; the post section is 21x11 in. Attached to this stern-frame are the after-brackets, also cast in one piece and weighing 55 tons each in the rough and 45 tons when finished for erection. The height of the flanged part of each bracket is 26 ft., and the width from center to center of bosses is 23 ft., the bosses themselves being 4 ft. 3 in. diameter by 5 ft. 7 in. deep. The forward brackets, which lie entirely inside the plating of the ship, will weigh 30 tons when erected. These are said to be the largest steel castings ever made in England.

ELECTRICALLY WELDED STEEL BARRELS are made at Uxbridge, England, by the Barrbeat-Stange Patent Barrel Syndicate. By easing the rolls at the ends the previously impossible task has been accomplished of rolling a flat steel sheet into the regulation barrel form. The sheet metal is extended at the center only, the metal plate retaining its original width at the ends. After the ends have been sheared the longitudinal seam is electrically welded by the Bernados process. The heads are cut in a circular shearing machine and then corrugated and dished in a 400-ton hydraulic press. The dished end fits inside the barrel head, and a ring of sheet metal ⅝ to 1 in. wide is also placed outside the barrel and the three edges of metal are finally electrically welded. The bungbosses are stamped out of steel and are also welded on by the same process. These barrels are principally used for storing lubricating and lighting oils and for holding the acetone used in the manufacture of cordite. The Uxbridge works have a capacity of 240 barrels per week, though space has been provided for an extension of output.

A CENTRAL LABORATORY FOR THE TESTING OF iron and steel is to be founded at Zurich, under the auspices of the International Society for Testing Materials of Construction, provided that the necessary funds can be raised. The society has sent out circulars pointing out the importance of such a laboratory and asking annual subscriptions for a period of ten years. Forty subscriptions of $250 per annum each would provide the necessary means, or $10,000 per year. Herr Krupp, of Essen, has already given his subscription of $250 per year and the Austrian iron-masters have subscribed a sum sufficient to insure $1,750 per annum. The English and American industries interested are now asked to assist. All communications should be sent to Mr. Bennett H. Brough, Secretary of the Iron and Steel Institute, London, England, who will forward them to the International Society.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Brooklyn Elevated Ry., Brooklyn, N. Y., June 27. Two men were at work on the track near the curve at Hudson and Myrtle Aves., when they were run down and killed by an extra train. The men had a schedule of the regular train and had first got back on the track after getting out of the way of one of these trains, when they were struck by the extra train, which came round the sharp curve. It does not appear that a flag was out to warn enginemen that trackmen were at work.

A CABLE CAR COLLISION, involving seven cars, occurred on Broadway, New York city, June 22, in which two persons were slightly injured. At Eighth St. a broken strand caught in the grip of a car, and carried the car ahead until it was pushing six other cars. The cable was stopped by the time the cars reached 15th St.

SEVERE EARTHQUAKE SHOCKS were felt in various parts of California on June 20. At Hollister and Gilroy walls were cracked, windows shattered, ceilings shaken down and chimneys and moveable articles overturned. No personal injuries and no loss of life are reported.

PART OF THE NEW ASPHALT LINING of the Queen Lane reservoir, Philadelphia, has shown signs of leaking before being accepted by the city, and Mr. John C. Trautwine, Jr., Assoc. M. Am. Soc. C. E., Chief of the Bureau of Water, has ordered the contractor to relay 3,000 sq. yds. It is stated that the lining used was not of sufficiently dense material.

SCARCITY OF WATER IN CHICAGO is already being complained of in many sections. It is said that the city water-works system has not kept pace in development with the growth in population. There is a large mileage of 4-in. mains and some of the pumping stations are without reserve engines. Reckless waste of water is largely responsible for the shortage. This is evident from the high consumption per capita, stated to be about 130 gallons.

WATER FILTERS FOR THE PUBLIC SCHOOLS OF Chicago are at last to be provided after months of agitation unless some new development occurs. Contracts have been awarded to install and maintain filters for 360 schools for three years at $88,000 for the period, as we understand the reports. The contract is divided equally between the Pasteur-Chamberland Co. of Dayton, O., and Geo. L. Squires of Buffalo. Aside from the schools covered by this contract 20 others are to be provided, through a previous arrangement, with apparatus for boiling and cooling the water.

THE PURCHASE OF EXISTING WATER-WORKS IN Montana was made compulsory by the legislature of 1894-5 wherever municipalities with private works in operation wished to establish plants of their own. The State Supreme Court has just declared this act unconstitutional in an appeal from a lower court made by the Consolidated Water Co. of Helena. The court holds that such compulsion on the part of the legislature is a violation of home rule, causing a municipality to buy works without regard to whether or not the plant meets the needs of the city and possibly incurring indebtedness in excess of the cost of a plant built by the city. Those interested further in the subject can find the opinion at some length, or an abstract, in the Helena "Herald" of June 7, 1897.

THE OHIO & LAKE ERIE SHIP CANAL REPORT is to be printed. The Provisional Committee has paid all its debts and there is a balance on hand sufficient to publish about 5,000 copies of the report and to prepare for pushing the project before the next regular session of Congress. The report will cover from 200 to 300 pages and contain about 30 illustrations of the commerce of Pittsburg harbor, together with commercial, topographical and location maps and profiles. The book will be edited by the Secretary, Mr. John E. Shaw, and will be ready for issue in about two months.

A QUARTER-MILE BICYCLE TRACK has just been completed for the Racine Athletic Association at Racine, Wis. The track was designed by Mr. C. E. Hawley, of New York city, and is very similar to the one-third mile track at Manhattan Beach, described in Engineering News of March 19, 1896. It was built under direction of Mr. John C. Quade, City Engineer of Kewanee, Ill.

ROBERT B. GORSUCH, THE FIRST SECRETARY AND TREASURER OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

In the preface to the "Historical Sketch of the American Society of Civil Engineers," recently published by the Society, the compiler regrets that he has been unable to obtain portraits of "the late" R. B. Gorsuch and Edward Gardiner, who served as the first and second Secretaries of the Society. By the courtesy of the correspondent whose letter appears below, we are now enabled to state that Mr. Gorsuch is still living, in full vigor of mind and body, and to present his portrait, from a photograph taken less than a year ago, and give some notes upon his professional career.

Sir: For the information of the members of the American Society of Civil Engineers, I would state that Major Robert B. Gorsuch, the first Secretary and Treasurer of the Society, is still living in the City of Mexico. On Oct. 23, 1852, when the initial step was taken in the formation of this society, he was one of the first men to respond to the call. From the beginning of the movement he was most active and enthusiastic, and much credit is due him for the successful organization of the American Society of Civil Engineers. At the first meeting, held on Nov. 5, 1852, at the Croton Aqueduct Department in Rotunda Park, Mr. James Laurie was elected President and Robert B. Gorsuch was made Secretary and Treasurer.

The fact that he is still living and distinguished in his profession in a foreign country makes him a personage of historical interest to the members of the Society of to-day. Maj. Gorsuch, as the first of the American colony to engage in engineering work in Mexico, is entitled to rank as the dean of his profession in that country and his work antedates all the railways in the Republic. He made the first surveys for the Mexican & Vera Cruz Ry., the beginning of railways in the Central Americas. He holds a high social position in Mexico, is the trusted friend of Mr. C. P. Huntington and represents him in all his business interests in the Republic. Although Maj. Gorsuch is now nearly 70 years of age, he does not appear to be over 50, and is a splendid specimen of an American gentleman. He spends much of his abundant means in charity; Gorsuch Hall, at the American Hospital, was given by him, and many of his countrymen can attest to his generosity in time of need, and he is highly respected by both Americans and Mexicans.

Maj. Gorsuch married a charming New York woman before his removal to Mexico and he and his wife have lived in the City of Mexico since long before the days of the Empire. He is thoroughly familiar with the Spanish language, and the habits and customs of the people of Mexico, and is an authority upon all matters pertaining to that country. He is a warm personal friend of President Diaz; has traveled many thousands of miles through the interior of Mexico, and is as active and as energetic in all matters pertaining to his business and to his profession as when he held the position of Secretary of the American Society of Civil Engineers.

Yours truly, Marie Robinson Wright.

Hoffman House, New York City, May 17, 1897.

SPECIFICATIONS FOR CEMENT SIDEWALK CONSTRUCTION.

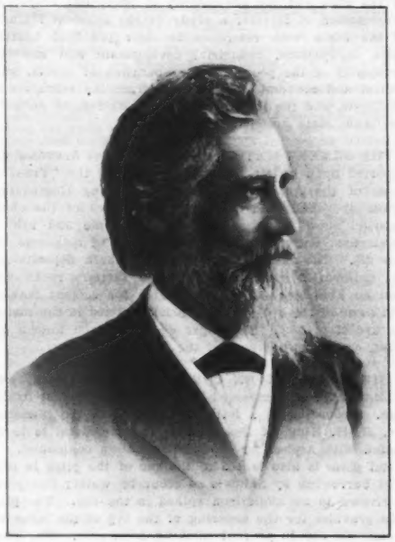
The construction of cement sidewalks is a character of work about which the engineer can find but very little specific information, either in the special text books or in the periodical literature of engineering. The details of construction of the pavement of this character so largely used in San Francisco, Cal., were given in our issue of March 4, 1897, and we present herewith an abstract from a specification for cement sidewalks, published in the journal of the Engineering Society of the School of Practical Science of Toronto, and written by Mr. A. J. McPherson:

The contractor shall excavate to a depth of 10 ins. below the level of the finished walk, and to a further depth than 10 ins., should circumstances require it in order to form a solid foundation. Any such excavation must be filled with gravel or other approved material, well watered, and rolled or pounded until quite solid. Upon the subgrade, excavated to as above, and filled so as to be uniformly solid, a foundation 6 ins. in depth, of broken stone, clean gravel or other approved material shall be laid, thoroughly watered, pounded and brought to an even surface.

Upon the foundation thus prepared a layer of concrete shall be laid in the following manner: It shall be composed of one part of fresh Portland cement of a quality approved by the engineer, and in accordance with the specifications for such as elsewhere described herein, and four parts of fine, clean, sharp gravel, free from clay, loam or dirt. The cement and gravel must be carefully measured and mixed while dry, then water must be added until the proper consistency is reached, and the whole must then be thoroughly worked over again. The concrete, when mixed as aforesaid, shall be immediately put in place and thoroughly rammed until it has an even surface, is perfectly and uniformly solid, and is 3 ins. in depth over the foundation, and within 1 in. of the finished surface of the walk. It shall then be divided into blocks as the engineer may direct, and the joints shall be filled with clean sand, or other approved separating material.

Upon the concrete layer prepared as aforesaid, and before it has had time to set, a wearing surface 1 in. in thickness shall be constructed. It must be composed of one part of Portland cement and two parts of clean, sharp sand or screened gravel of approved quality, which shall pass through a ⅝-in. mesh and be entirely free from clay, loam or dirt. The cement and sand or gravel must be mixed dry and then moistened, but it must be used as dry as practicable and be immediately put in place on the completion of the mixing. The layer must then be rammed or pounded and the surface worked so as to be true and even. A layer of best Portland cement must then be sifted over the surface to act as a dryer and to give a smooth finish to the walk, and the whole well trowelled to a perfectly even plane.

The foundation, concrete layer and wearing surface shall be of uniform depth throughout the walk, and shall be constructed so that the finished surface shall have a slope of ¼ in. in 1 ft. towards the roadway, unless otherwise



directed. The joints on the surface shall be cut to correspond exactly with those in the concrete and finished in a neat manner, and the edges of the walk must be neatly rounded.

Stone curbing, of dimensions and quality as approved by the engineer, must be set when required along the outer line of the sidewalk in an accurate manner and true to the lines and levels given. A piece of 2 × 6-in. pine, dressed so as to be perfectly straight on its edges, shall be furnished and set on edge along each side of the walk, before the concrete is put in place, by the contractor, and shall be removed by him after the cement has become hard. When removing the piece, sodding or other work that may have been done must not be injured, and the space left must be filled with good soil and neatly packed in place. On street crossings a 4 × 6-in. white oak or cedar curbing shall be firmly fixed at each side in a permanent manner so as to protect the edge of the walk.

The contractor must carefully fit the pavement around all water-works, service boxes, coal chutes, down pipes, projecting steps, door sills, etc., and must take special care to prevent injury to any works or appliances that may be in or under the walk. Approved iron gratings, covers, etc., for areas shall be furnished the contractor by the town or owners of properties, and he must then place them, when so required, in true position to conform to the plane of the surface of the sidewalk. At lanes and private driveways the edges of the walks shall be faced with the cement mortar used for the surface to the bottom of the concrete, and if required the edges shall be rounded off and the surface marked in blocks or indicated to give a foothold to horses. On street crossings the concrete base shall be 3½ ins. thick and the surface layer shall be 1½ ins. thick and composed of equal quantities of cement and of screened gravel or sand.

EXCESSIVE PRECIPITATION IN THE UNITED STATES.

By Alfred J. Henry.

Vast sums of money are expended each year in the construction of sewers and drainage systems. In the designing of main sewers for large areas a thorough knowledge of the vicissitudes of rainfall of the region, particularly as regards the intensity and duration of the heavier falls, is essential.

A number of quite heavy rainstorms occurred during the past year, and in many cases the capacity of the sewers was not equal to the task of discharging the accumulated storm waters. Failure of sewers to carry off flood waters is not a new problem in municipal engineering, though it has cost in damage to property and resulting litigation many thousands of dollars.

At the request of a number of civil and municipal engineers, Prof. Willis L. Moore, Chief of Bureau, has directed that statistics of unusually heavy rains be published in greater detail than heretofore. The facts and figures herein presented may be considered as a first attempt to draw some useful deductions from the records of automatic rain gages in use at Weather Bureau stations.

Excessive rains naturally fall into two broad classes, (a) rains of great intensity and short duration, and (b) light intensity and long duration. Of these two classes, those of the first are by far the most damaging and destructive. In extreme cases 95% of the downpour may quickly find its way into natural or artificial drainage channels. A rainfall of one-half inch in linear depth represents about 11,312 imperial gallons per acre. Assuming that in extreme cases only 5% is absorbed, it is easily seen how great a quantity of water must flow into the drainage channels.

On the Pacific Coast, particularly the coast of Washington and Oregon, where the annual rainfall is greater than in any other portion of the United States, excessive rains of class a are not prevalent. The rain of this region falls principally between September and May, the colder part of the year, when convectional overturning in the atmosphere is least active.

The most favorable conditions for the sudden condensation of a vast quantity of water vapor are conceived to be (1) a strong vertical temperature gradient; (2) high surface temperature and humidity, in fact, the general conditions of humidity and instability of the atmosphere necessary to the formation of thunderstorms and tornadoes.

The most violent rains of class a, and, at the same time, those of which the least is known, are the so-called cloudbursts of the mountainous and arid regions of the West. These storms are not confined to any particular state or region, but may occur in mountainous localities throughout the entire territory bounded by the British possessions on the north, and Mexican border on the south, the foothills of the Rockies on the east and the Sierras on the west. In the true cloudburst the rain seems to pour down rather than fall in drops, and, as a rule, the downpour of water covers an extremely small area. It often happens that the downpour occurs over rather narrow basins or on mountain slopes whose outlets are canyons or gorges leading to a valley or plain below. In these cases almost the entire amount of water quickly finds its way into the drainage channel, and, as a result, a wave of water rushes down the outlet with considerable velocity and in sufficient volume to destroy everything in its path. Such a flood wave almost swept away the town of Eureka, Nev., in 1874, and caused the loss of 15 lives. A far greater disaster occurred in Bear Creek Canyon, Colo., in July, 1896. Thirty lives were lost and property valued at more than $100,000 was destroyed.

The amount of rain that falls in one of these torrential downpours has never been ascertained. A cloudburst passed over the edge of the little town of Palmetto, Nev., in August, 1890. A rain gage that was not exposed to the full intensity of the storm caught 8.80 ins. of water in an hour. In August, 1891, two storms passed over Campo, Cal., within a few minutes of each other. The second storm was a veritable cloudburst. The observer succeeded in measuring the rainfall of the first shower and a portion of the second. Eleven and a half ins. were measured within an hour. The rain gage and support were carried away by the torrent of water in the second storm and the full record was not obtained.

The great majority of excessive rains (class a) in the United States occur east of the 105th meridian, and principally in the summer months. They are most frequent in connection with summer afternoon thunderstorms, but occasionally occur in the track of West India hurricanes.

*Extract from the "Monthly Weather Review," January, 1897.

They are more abundant on the Gulf and south Atlantic coasts than at inland points.

In the accompanying table there are given the essential facts concerning each excessive rain of which permanent record was made during 1896, at stations equipped with self-recording rain gages. Columns 1 and 2 give the total duration of the storm; column 3, the total depth of rainfall; columns 4 and 5, the beginning and ending, respectively, of the excessive rate; column 6, the amount of rain that fell before the excessive rate began. In the succeeding columns the accumulated amounts of rainfall are given for each successive five minutes of the storm's duration up to fifty minutes, and in ten and twenty minute periods thereafter.

It is possible to determine from the details thus presented whether or not rain falls at a uniform rate and how long such rate continues, and also the approximate time when the flow in the sewers shall be at a maximum for any given rate.

It is generally assumed that in heavy showers the intensity, i, varies inversely as the duration, t, and a number of formulae have been suggested to express the relation between i and t. From an examination of the data in the table it would seem to be extremely doubtful whether a relation sufficiently definite to admit of expression by mathematical formulae exists. The general principle that rains of the highest intensity exhaust themselves quickly holds good, but the fact remains that the total duration of the storm bears no simple relation either to the rate or linear depth of rainfall.

In the table the amounts given in column 6 are always included in those of column 3. Whenever possible the full record of the storm before the beginning of the excessive rate, but not after, has been given in the columns under "Depths of precipitation, etc."

The periods of very great intensity are of short duration and may occur at any time during the continuance of the storm. There may be two and even three periods of great intensity in a single storm separated by intervals of light rain. The following table shows the time of occurrence of the maximum intensity, counting from the beginning of the storm, of all storms that occurred at Washington, D. C., during the period 1881-1896, and at Savannah, Ga., and St. Louis, Mo., 1889-1896:

Percentage of cases in which the maximum intensity of rainfall occurred within 5 to 60 minutes from the beginning of the storm.

Maximum intensity occurred.	Washington. Per cent.	Savannah. Per cent.	St. Louis. Per cent.
Within 5 minutes from beginning of storm.....	17	10	32
Within 10.....	21	20	30
" 15.....	20	21	8
" 20.....	5	13	5
" 25.....	8	7	2
" 30.....	9	10	2
" 35.....	5	5	2
" 40.....	5	1	8
" 45.....	2	4	5
" 50.....	1	5	5
" 60.....	6	3	2

If we select from the whole number of individual storms those shorter periods during which a very high rate was maintained, and plot the rates per hour as abscissae in a system of rectilinear co-ordinates we obtain, after connecting the points so plotted, a curve of probable maximum intensity.

Thus we find that at Washington during the last 16 years the highest rate per hour for any

5	consecutive mins.	was	7.50	ins., Sept.	3, 1882.
10	"	"	5.10	" "	16, 1888.
15	"	"	4.50	" June	27, 1881.
20	"	"	3.90	" "	27, 1881.
25	"	"	3.60	" "	27, 1881.
30	"	"	3.15	" "	27, 1880.
40	"	"	2.75	" "	10, 1876.
50	"	"	2.30	" "	10, 1876.
60	"	"	1.98	" "	10, 1876.
120	"	"	1.23	" July	26, 1886.

A NEW FORM OF TRANSMISSION DYNAMOMETER.*

By Frederick Bedell.† Assoc. M. Inst. Elec. E.

The apparatus which forms the subject of this paper has not been employed as a dynamometer, but has been used for some years in a different form in experiments upon synchronous motors. The instrument has given such satisfaction that it is with confidence that the application of the principle to the transmission dynamometer is advocated.

*A paper presented at the Hartford meeting of the American Society of Mechanical Engineers.

†Professor of Physics, Cornell University, Ithaca, N. Y.

The dynamometer is shown in Figs. 1 and 2, which have been drawn to show the relation of the parts rather than the actual construction of the instrument. The shafts S and S', are the two shafts between which the power is transmitted; these are arranged in line and with ends abutting. The shafts are connected by any convenient system of springs; this system may consist of a single spring or a number of springs, which may be either for tension, torsion or compression. The annular disc D, supported by the frame G, is carried by the shaft S. A similar disc D', supported by the frame or spider F, is carried by the shaft S'. In the particular form shown, the frame G carries four lugs B, which are connected to the spider F by the springs BC, which may be either springs for tension or compression.

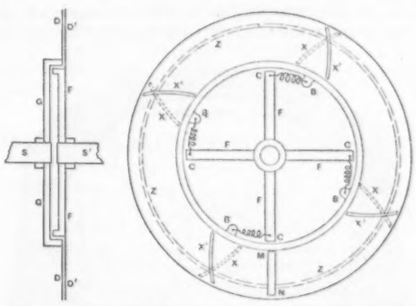


Fig. 1.—Transmission Dynamometer. Designed by Dr. Frederick Bedell, Ithaca, N. Y.

The exact arrangement of the spring connection between the shafts S and S' has no direct bearing upon the principle of the dynamometer, and any form of connection may be employed which is found most convenient.

Let us suppose that we have the shafts S and S' running, let us say, at a constant speed and with a variable load; that is, the shaft S is transmitting an unknown and varying amount of power to the shaft S'. When the shafts are idle they have a certain angular position with relation to each other. When they transmit power, however, the shafts depart from the zero position with reference to each other by an angle θ, which depends upon the strength of the springs and the torque between the two shafts.

To determine the amount of power transmitted from one shaft to the other it remains to determine this angle θ, by which one shaft is displaced with reference to the other. This angle θ may be determined by the following simple method, which constitutes the distinctive feature of this dynamometer:

In the disc D are slits X, X, X, X; corresponding slits X', X', X', X' are in the disc D'. These slits are slightly curved, as shown in Fig. 2, the exact curvature necessary being explained later. The slits in one of the discs are the exact counterpart of the slits in the other disc, curving, however, in the opposite direction. The slits thus superposed give a single point of intersection. As the shaft S' is turned through an angle θ with reference to the shaft S, the slits X' shift with reference to the slits X, and the point of intersection of the two slits is accordingly moved inward or outward from the center of the discs. The openings formed by the intersections of the

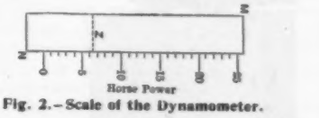


Fig. 2.—Scale of the Dynamometer.

slits will show a continuous ring of light Z, if the discs are illuminated from behind. For a constant torque the position of this ring of light will remain constant. The ring of light will, however, move inward or outward as the torque varies.

The slits are made of such a curvature that the change in the radius of the circle of light Z is directly proportional to the change in the angle θ, that is, to the torque.

The instrument may be direct reading, and experience has shown the following form to be convenient. An incandescent lamp is placed behind the discs. This lamp is enclosed in a suitable opaque box so that it illuminates only the disc. In front of the discs is a stationary opaque screen covering entirely the whole apparatus. In this screen is a ground-glass window MN (see Fig. 2). The incandescent lamp is behind the two discs and directly opposite this window. Instead of a complete circle of light Z we only see a line of light across this window. The scale at the side of this window shows the horse-power direct for a given speed, as shown in Fig. 3. As explained above, the slits are made of such a curvature that the divisions of the scale in Fig. 3 are equal. The position of the line Z in Fig. 3 indicates 6.3 HP. at a speed, let us

TABLE SHOWING THE ACCUMULATED AMOUNTS OF PRECIPITATION FOR EACH FIVE MINUTES DURING ALL STORMS OF 1896 IN WHICH THE RATE EQUALED OR EXCEEDED 1 IN. PER HOUR AT ALL STATIONS OF THE WEATHER BUREAU FURNISHED WITH SELF-REGISTERING RAIN-GAGES.

Station and date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time. 5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.
1	1	2	3	4	5	6											
Baltimore, Md.																	
July 21, 1896	9.15 p.m.	11.58 p.m.	2.05	9.50 p.m.	10.40 p.m.	0.05	0.21	0.35	0.46	0.56	0.62	0.64	0.67	0.70	0.83	0.9o	1.19
September 19, 1896	4.55 p.m.	5.40 p.m.	1.00	5.15 p.m.	5.40 p.m.	0.05	0.25	0.60	0.85	0.98	0.95	.....	.....	.....	.....	.....	.....
Chicago, Ill.																	
May 25, 1896	1.37 a.m.	2.30 a.m.	1.46	2.08 a.m.	2.25 a.m.	0.09	0.01	0.09	0.38	1.07	1.26	1.39	1.31	1.32	...	.....	.....
August 6, 1896	6.05 a.m.	7.35 a.m.	1.18	6.05 a.m.	6.45 a.m.	0.00	0.19	0.30	0.36	0.62	0.89	0.99	1.04	1.17	.....	.....	.....
Cincinnati, Ohio.																	
July 30-31, 1896	9.45 p.m.	12.30 a.m.	1.93	9.48 p.m.	10.27 p.m.	0.02	0.14	0.30	0.42	0.55	0.62	1.00	1.05	1.12	1.16	1.19	1.21
Cleveland, Ohio.																	
April 30, 1896	3.25 p.m.	5.00 p.m.	1.64	3.27 p.m.	4.00 p.m.	0.05	0.28	0.58	0.88	1.13	1.33	1.36	1.49	1.53	.....	.....	.....
June 8, 1896	11.00 a.m.	12.55 p.m.	1.87	11.19 a.m.	11.47 a.m.	0.04	0.04	0.19	0.49	0.79*	1.04*	1.21*	1.58	1.68	1.73	1.76	.....
Denver, Colo.																	
July 25, 1896	3.53 p.m.	4.22 p.m.	1.08	3.57 p.m.	4.09 p.m.	0.05	0.05	0.30	0.60	0.78	0.95	1.02	.....	.....	.....	.....	.....
Detroit, Mich.																	
June 30, 1896	5.50 p.m.	6.40 p.m.	1.19	5.58 p.m.	6.28 p.m.	0.05	0.15	0.45	0.85	1.00	1.07	1.14	.....	.....	.....	.....	.....
July 26-27, 1896	8.15 p.m.	5.00 a.m.	2.03	8.17 p.m.	8.58 p.m.	0.02	0.38	0.57	0.65	0.91	1.15	1.30	1.43	1.66	1.70	1.73	1.78
Dodge City, Kans.																	
April 16, 1896	4.45 p.m.	5.46 p.m.	1.09	5.05 p.m.	5.40 p.m.	0.05	0.05	0.15	0.40	0.65	0.80	0.97	1.13	1.30	1.35	.....	.....
July 15, 1896	1.45 a.m.	2.55 a.m.	1.18	1.45 a.m.	2.15 a.m.	0.00	0.19	0.35	0.59	0.78	0.91	1.00	1.06	1.11	.....	.....	.....
Galveston, Tex.																	
March 15, 1896	6.00 a.m.	6.00 p.m.	2.17	11.30 a.m.	11.47 a.m.	0.35	0.10	0.30	0.37	0.47	0.62	0.75	0.82	0.86	0.88	0.90	1.00
July 11, 1896	12 noon	8.30 p.m.	1.67	2.07 p.m.	2.52 p.m.	0.32	0.30	0.45	0.57	0.65	0.77	0.90	0.96	1.04	1.10	1.13	1.23
Indianapolis, Ind.																	
May 26, 1896	5.40 a.m.	6.00 a.m.	1.01	5.40 a.m.	6.05 a.m.	0.00	0.30	0.50	0.90	0.93	1.01	.....	.....	.....	.....	.....	.....
September 18, 1896	10.30 p.m.	11.40 p.m.	1.78	10.35 p.m.	11.10 p.m.	0.05	0.05	0.29	0.48	0.65	0.80	1.00	1.30	1.50	1.65	1.75	1.78
Jacksonville, Fla.																	
March 11, 1896	6.30 a.m.	10.15 a.m.	1.20	6.38 a.m.	9.07 a.m.	0.10	0.14	0.30	0.85	0.95	0.90	1.01	.....	.....	.....	.....	.....
June 4, 1896	2.25 p.m.	4.55 p.m.	2.49	2.55 p.m.	3.30 p.m.	0.12	0.07	0.14	0.47	0.82	1.30	1.57	1.66	1.60	1.71	1.79	1.99
June 19, 1896	8.05 p.m.	8.40 p.m.	1.33	8.05 p.m.	8.55 p.m.	0.00	0.30	0.61	0.70	0.77	0.82	0.85	0.87	0.89	1.00	1.15	.....
August 4, 1896	1.30 p.m.	2.30 p.m.	1.71	1.30 p.m.	2.05 p.m.	0.05	0.04	0.26	0.44	0.69	0.81	0.91	1.04	1.12	1.15	1.18	.....
August 26, 1896	3.04 p.m.	6.15 p.m.	3.09	3.17 p.m.	4.00 p.m.	0.15*	0.09*	0.11*	0.58*	0.84*	0.50	0.65	1.06	1.30	1.50	1.95	1.80
Jupiter, Fla.																	
January 25, 1896	5.30 p.m.	10.30 p.m.	2.18	6.40 p.m.	7.21 p.m.	0.35	0.08	0.06	0.10	0.16	0.30	0.42	0.51	0.66	1.06	1.36	1.58
July 10, 1896	4.00 p.m.	10.30 p.m.	2.17	8.00 p.m.	8.40 p.m.	0.07	0.10	0.25	0.35	0.39	0.47	0.75	0.90	1.10	.....	.....	.....
September 9, 1896	10.30 p.m.	12 noon	1.25	10.30 a.m.	11.19 a.m.	0.00	0.07	0.24	0.51	0.73	0.88	0.96	1.01	1.10	1.14	1.17	.....
Kansas City, Mo.																	
May 31, 1896	5.55 a.m.	7.35 a.m.	1.17	6.29 a.m.	6.38 a.m.	0.19	0.60	1.05	.....	.....	.....	.....	.....	.....	.....	.....	.....
July 18-19, 1896	9.30 p.m.	7.30 p.m.	5.54	3.50 p.m.	5.05 p.m.	0.19	0.05	0.15	0.40	0.65	1.00	1.30	1.58*	1.74*	1.87*	1.99*	2.28*
Key West, Fla.																	
November, 7, 1896	2.30 p.m.	4.10 p.m.	1.00	2.50 p.m.	3.41 p.m.	0.14	0.03	0.10	0.25	0.39	0.54	0.35	0.45	0.65	0.83	0.86	.....
Little Rock, Ark.																	
June 9, 1896	10.20 a.m.	11.35 a.m.	1.11	10.43 a.m.	11.05 a.m.	0.05	0.28	0.50	0.75	0.95	1.02	1.05	1.05	.....	.....	.....	.....
October, 29, 1896	9.30 a.m.	11.45 a.m.	1.75	10.32 a.m.	10.54 a.m.	0.79	0.06	0.32	0.48	0.60	0.68	0.70	0.73	0.76	0.79	0.88	0.91
Louisville, Ky.																	
June 28, 1896	4.17 p.m.	4.33 p.m.	1.27	4.30 p.m.	4.46 p.m.	0.05	0.30	0.65	1.00	1.30	.....	.....	.....	.....	.....	.....	.....
July 4, 1896	5.58 p.m.	6.35 p.m4.	4.60	6.05 p.m.	7.46 p.m.	0.15	0.06	0.15	0.70	1.30	1.82	1.70	1.88*	2.08*	2.32*	2.38*	2.70*
Nantucket, Mass.																	
July 6, 1896	6.05 p.m.	10.25 p.m.	1.61	9.23 p.m.	10.23 p.m.	0.25	0.13	0.24	0.37	0.42	0.48	0.49	0.55	0.60	0.64	0.75	1.15
Nashville, Tenn.																	
May 31, 1896	1.15 p.m.	2.25 p.m.	1.34	1.46 p.m.	2.20 p.m.	0.15	0.05	0.08	0.30	0.31	0.40	0.64	0.79	0.90	1.12	1.22	.....
July 2, 1896	5.37 p.m.	6.18 p.m.	1.23	4.58 p.m.	5.40 p.m.	0.12	0.05	0.13	0.44	0.60	0.72	0.78	0.78	0.80	0.95	0.97	1.21
July 13, 1896	5.38 p.m.	6.18 p.m.	1.50	5.58 p.m.	6.38 p.m.	0.00	0.13	0.30	0.49	0.83	1.05	1.11	1.13	1.13	1.14	1.15	1.30
New Orleans, La.																	
March 10, 1896	2.30 p.m.	9.30 p.m.	1.21	6.37 p.m.	7.08 p.m.	0.30	0.05	0.15	0.25	0.30	0.35	0.40	0.48	0.65	0.95	1.05	1.09
March 18, 1896	1.10 p.m.	6.30 p.m.	2.32	2.11 p.m.	3.06 p.m.	0.25	0.13	0.18	0.39	0.55	0.62	1.45	1.52	1.55	1.44	1.50	1.53
April 9, 1896	1.30 p.m.	2.30 p.m.	1.07	1.30 p.m.	1.50 p.m.	0.00	0.13	0.40	0.72	0.93	1.45	1.61	1.55	.....	.....	.....	.....
April 14, 1896	1.30 p.m.	7.40 p.m.	1.52	3.43 p.m.	4.31 p.m.	0.15	0.04	0.21	0.44	0.60	0.64	0.67	0.79	0.95	0.99	1.07	1.11
September 6, 1896	6.25 a.m.	5.15 p.m.	3.31	9.45 a.m.	10.40 a.m.	0.00	0.04	0.09	0.15	0.24	0.34	0.46	0.63	0.99	1.22	1.44	1.67
New York, N. Y.																	
July 6, 1896	12.10 p.m.	1.30 p.m.	1.06	12.23 p.m.	1.19 p.m.	0.00	0.20	0.42	0.60	0.85	0.99	0.94	0.99	1.01	.....	.....	.....
Norfolk, Va.																	
June 9, 1896	2.47 p.m.	6.30 p.m.	1.45	3.47 p.m.	3.58 p.m.	0.00	0.25	0.49	0.55	1.00	1.17	1.25	1.35	1.44	.....	.....	.....
June 28, 1896	5.13 p.m.	6.40 p.m.	1.30	5.18 p.m.	5.49 p.m.	0.00	0.10	0.27	0.36	1.00	1.06	1.10	.....	.....	.....	.....	.....
July 16, 1896	7.35 p.m.	8.35 p.m.	1.04	7.38 p.m.	8.00 p.m.	0.05	0.05	0.25	0.35	0.50	0.57	0.95	1.01	.....	.....	.....	.....
Omaha, Nebr.																	
August 18, 1896	6.39 p.m.	7.54 p.m.	1.02	6.57 p.m.	7.00 p.m.	0.05	0.25	0.70	1.10	1.45	1.02	.....	.....	.....	.....	.....	.....
Pittsburg, Pa.																	
August 12, 1896	7.50 a.m.	11.40 a.m.	2.22	8.38 a.m.	9.31 a.m.	0.10	0.07	0.25	0.30	0.85	1.06	1.13	1.21	1.36	1.37	1.44	1.79
Portland, Me.																	
September 6, 1896	8.15 a.m.	5.00 p.m.	5.21	7.30 a.m.	8.30 a.m.	1.06	0.13*	0.24*	0.35*	0.49*	0.52	0.60	0.66	1.13	1.26	1.36	1.56
St. Louis, Mo.																	
May 27, 1896	3.45 p.m.	10.05 p.m.	2.09	6.04 p.m.	7.00 p.m.	0.01	0.08	0.17	0.25	0.49	0.73	0.85	0.93	0.99	1.05	1.29	1.33
	.....	.....		7.28 p.m.	7.55 p.m.	0.12	0.23	0.50	0.60	0.70	0.70	0.71	0.71	0.71	0.76	0.89*	1.01
St. Paul, Minn.																	
August 4, 1896	12.08 a.m.	12.28 a.m.	1.52	12.08 a.m.	12.28 a.m.	0.00	0.10	0.46	0.84	1.34	1.44	1.58	.....	.....	.....	.....	.....
August 9, 1896	4.15 p.m.	6.10 p.m.	1.07	4.15 p.m.	4.55 p.m.	0.00	0.06	0.19	0.39	0.59	0.61	0.69	0.95	1.00	1.07	.....	.....
Savannah, Ga.																	
April 24, 1896	5.30 p.m.	8.45 p.m.	1.36	7.06 p.m.	7.37 p.m.	0.30	0.05	0.10	0.13	0.23	0.30	0.45	0.67	0.80	0.97	0.98	1.08
July 7, 1896	9.45 a.m.	11.10 a.m.	1.34	9.58 a.m.	10.18 a.m.	0.05	0.02	0.05	0.20	0.65	0.90	1.05	1.10	1.11	1.13	1.13	1.15
August 15, 1896	6.45 p.m.	10.45 p.m.	2.06	8.35 p.m.	8.55 p.m.	1.49*	0.05	0.09	0.70	0.95	1.00	.....	.....	.....	.....	.....	.....
August 26, 1896	4.30 a.m.	5.35 a.m.	1.02	4.45 a.m.	5.15 a.m.	0.19	0.05	0.06	0.15	0.27	0.38	0.48	0.97	1.25	1.46	1.97	1.98
Vicksburg, Miss.																	
April 12, 1896	1.30 p.m.	7.15 p.m.	1.03	1.36 p.m.	2.20 p.m.	0.05	0.04	0.15	0.25	0.60	0.88	0.78	0.84	0.90	0.96	1.03	1.07
June 6, 1896	5.25 p.m.	8.55 p.m.	1.02	5.34 p.m.	5.57 p.m.	0.05	0.08	0.09	0.15	0.50	0.52	1.03	1.05	1.09*	1.20*	1.24*	1.25*
October 28-29, 1896	9.40 p.m.	8.15 a.m.	1.38	5.31 a.m.	5.48 a.m.	0.05	0.19	0.45	0.61	0.69	0.68	0.72	0.76	.....	.....	.....	.....
Washington, D. C.																	
August 12, 1896	5.30 p.m.	6.24 p.m.	1.73	6.28 p.m.	7.00 p.m.	0.05	0.14	0.33	0.75	0.95	1.13	1.34	1.45	1.52	1.57	.....	.....
Wilmington, N. C.																	
August 8, 1896	1.25 p.m.	3.45 p.m.	1.19	1.29 p.m.	2.39 p.m.	0.05	0.19	0.30	0.75	0.90	1.06	1.07	1.08	1.09	.....	.....	.....

*Partly estimated. †Fell in three short heavy showers of about equal amounts, at intervals of nearly 1 hour.

say, of 400 revolutions per minute. When the speed is not maintained constant, it is necessary to determine the speed and to correct the reading accordingly.

It is thought that such a dynamometer, being simple and direct reading, will prove convenient not only in testing dynamos, turbines, engines and revolving machinery of all sorts, but that it will find a useful place in power-houses and factories. Thus the engineer in charge of a station, cable-house or factory can at a glance see the exact amount of power which is being used, and he can regulate his turbines or the supply of steam to suit the demands.

TUNNEL ROOF SHIELD USED IN THE BOSTON SUBWAY.

In the article on the Boston subway for electric cars, in our issue of Feb. 4, mention was made of the use of a shield for driving the roof portion of

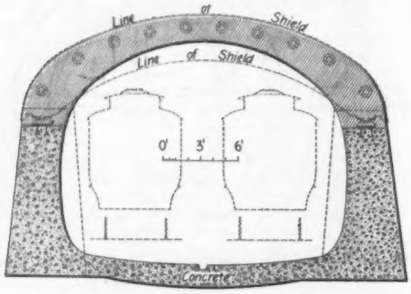


Fig. 1.—Section of Boston Subway Showing Position of Roof Shield and Jacks used in Tunneling.

the excavation where the work was done by tunnelling instead of by excavation, and we illustrate this week the form of shield used.

This method of working was employed in Section No. 6, which extends under the narrow portion of Tremont St., from Park St. to Court St., and the form of cross-section is shown in Fig. 1, which also shows the position of the shield and of the hydraulic jacks used in driving the shield. The contract for the construction of this section of the subway was awarded to R. A. Malone, on May 9, 1896, and work was commenced on May 14. According to the provisions of the contract the "slice" method (already described in our former

Fig. 2.—Half Elevation of Rear of Shield, Showing Position of Jacks. (From a Model.)

Fig. 3.—Half Elevation of Front and Cutting Edge of Shield. (From a Model.)

article) was allowed for a short distance at each end, the middle portion to be done by tunneling, with one or more tunnel drifts for each side wall. The contractor was allowed to adopt any approved system of tunneling, or, if he should find such a method to be practicable, to excavate for the arch and for any portion of the core by means of a roof shield spanning the distance between the side walls and driven forward by jacks bearing against the completed portion of the roof arch.

Some experimental work was done by the contractor on the crown bar system, but this caused settlement of the street surface, and further work on this system was prohibited. An extension of the "slice" system was then started, but, as stated in the report of the Boston Transit Commission, the work did not progress satisfactorily, and complaints were made as to the unsatisfactory manner of timbering. A slight cave-in occurred on Aug. 10, owing to a leak in an old 12-in. water pipe and to poor bracing, and as a result of this the Commission, late in August, directed the Chief Engineer, Mr. H. A. Carson, M. Am. Soc. C. E., to carry on the work by men employed directly by the commission.

The engineer then decided to employ the shield system referred to in the specifications. He had had a design made for such a shield some weeks before the contract was let for Section No. 6, and at a later time had two other different designs prepared. The shield actually constructed is built according to the last design. Suggestions as to this design were made by Mr. J. R. Worcester, Mr. H. H. Marden, Jr., and Mr. C. R. Perry, as well as by the Chief Engineer. The shield was built by the James Russell Boiler Works Co., of South Boston, Mass., and the hydraulic apparatus was made by the Watson & Stillman Co., of New York city. The weight is about 22 tons, and the shield is calculated to sustain an approximate load of 640,000 lbs. The cost of the shield and appurtenances complete was about $6,000, exclusive of various changes in the cross-section excavated, some of which add to while others lessen the cost of the subway.

The general form of the shield is shown in Figs. 2 and 3, which are reproduced from photographs of a model. Fig. 2 is the cutting edge, the projecting face of the roof being supported by triangular brackets or gusset plates, against the backs of which the hydraulic jacks take their bearing. Fig. 3 is the rear side of the shield, with the jack plungers projecting through holes in the web.

The shield, Fig. 4, is 29 ft. 4 ins. wide over all, and has a rise of 4 ft. 4 5-16 ins. It is composed of two plate girders 3 ft. 8 ins. deep, 4 ft. apart, with cover plates or roof plates extending 4 ft. beyond the girders, while an additional top plate extends 24 ins. at the rear. Under each end or foot of each girder is an iron casting with a spherical projection on the under side, which fits into a recess in a cast steel shoe, the surfaces in contact being planed to exactly spherical form. The shoes rest upon two lines of 10-in. steel I-beams embedded in the tops of the concrete side walls, these beams forming a track upon which the shield slides when being driven forward. All rivets are ⅞-in. diameter, and all rivet holes 15-16-in. diameter. In metal ½-in. thick, or less, the holes are punched to exact size. In metal over ½-in. thick the holes are drilled or punched ⅛-in. less than the finished diameter, and reamed to size. All castings are attached to the girders by 15-16-in. turned bolts.

The girders are divided into ten panels, with transverse webs of ⅝-in. plate, forming compartments between the girders, and there is a 6-in.

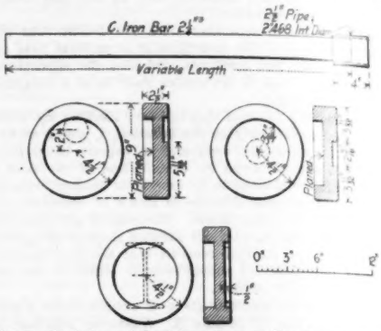


Fig. 5.—Sockets and Cast-Iron Bars to Receive the Thrust of the Hydraulic Jacks.

hydraulic jack to each panel, the jacks being placed between the girders. The closed ends of the jacks are supported by the castings shown in Fig. 4, which are bolted to the web of the front girder. The jacks have 6-in. plungers, which pass through 10½-in. holes in the web of the rear girder, and the outer ends of the plungers fit into collars, Fig. 5, behind which are 2¼-in. cast-iron bars about 2 ft. 10 ins. long, with 2½-in. pipe sleeves at the joints. These bars are built into the brickwork of the tunnel roof, and form continuous lines of metal to resist the thrust of the jacks. The suggestion of using continuous horizontal struts of iron embedded in the masonry for the hydraulic jacks to react against was made to Mr. Carson four years ago, or more, by Mr. Walton I. Aims, of New York. The pipes to the jacks are brought together under the rear of the shield and fitted with valves, so that a man at this point can direct and regulate the direction of the advance of the shield by varying the pressure on individual jacks. The whole movement is controlled in this way, men at each side watching and measuring the advance simultaneously. As soon as the shield has been moved forward a length of about 3 ft., the timber centering is erected behind it and the brick arch built. During this time a heading 6 ft. high, and the whole width of the tunnel is excavated ahead of the shield, the roof being supported by posts and poling boards, which are removed as the shield reaches them. The material encountered is mainly gravel and stiff clay, and the depth of earth above the tunnel roof is from 6 ft. 9 ins. to 13 ft. 6 ins.

The progress made by the shield was about 50 ft. per week, and it has been used to excavate a length of about 550 ft. by this method. There were no accidents or serious difficulties in connection with the use of the shield.

Tunnel roof shields on this same general plan have been used in two other cases of excavation under city streets and it may be of interest to give some general particulars of these in this article.

Baltimore Belt Line Tunnel.—In part of the work on the York Road tunnel of the Baltimore Belt Line R. R., in 1892, the lower part was excavated by rectangular shields, and the roof by a semicircular shield 15 ft. 4 ins. diameter, 13 ft. 8 ins. long. This was pushed forward by 12 hydraulic jacks, each of 100 tons capacity, the shield sliding on plates riveted to the feet, and resting on cast-iron plates on top of the caps of the bottom drifts. To prevent the jacks from crushing the brickwork of the tunnel arch the head of each jack was fitted with a cast-iron socket, 15 ins. square, bolted to a segmental timber 22×47 ins., 8 ins. thick, these segments conforming to the curve of the shield. This shield was described in our issues of Jan. 9 and 16, 1892. As recorded in our issue of July 9, 1896, it failed on account of the

settling of the crown and the spreading of the haunches. This was due to the light construction of the shield in proportion to its great diameter and the heavy load of unstable clay which it had to support. This shield, therefore, had to be abandoned.

Paris Sewer Tunnel.—In building a large outfall sewer at Paris, France, in 1896, part of the work

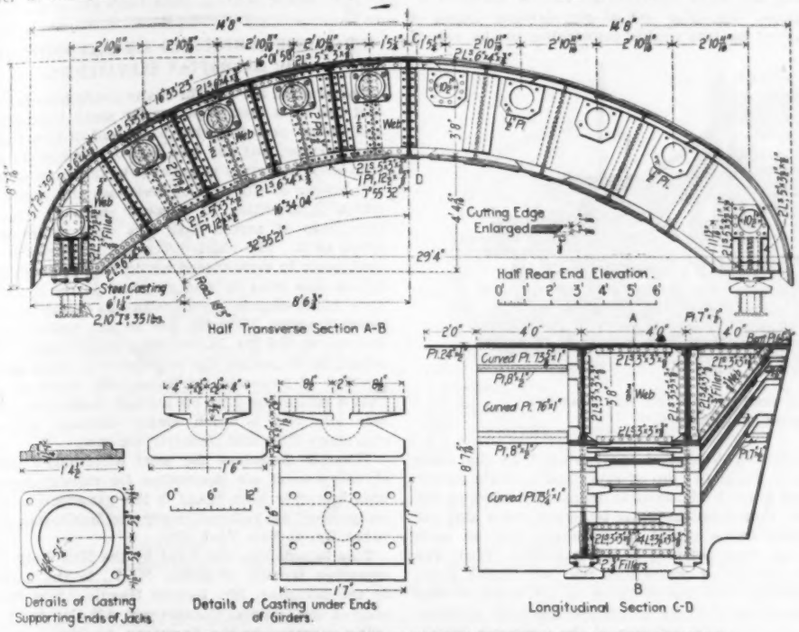
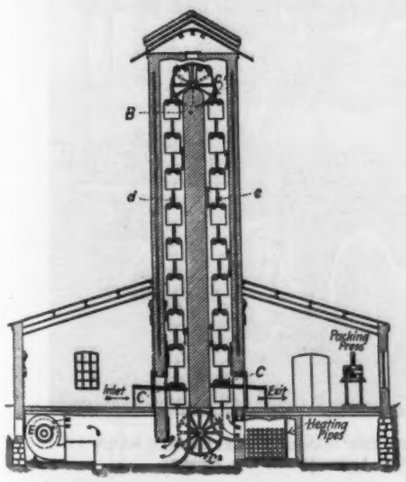

Half Transverse Section A-B
Half Rear End Elevation.
Cutting Edge Enlarged
Steel Casting
Details of Casting Supporting Ends of Jacks
Details of Casting under Ends of Girders.
Longitudinal Section C-D

FIG. 4.—DETAILS OF ROOF SHIELD USED IN TUNNELING FOR THE BOSTON SUBWAY.
H. A. Carson, M. Am. Soc. C. E., Chief Engineer.

was done by means of a roof shield, 23 ft. 9 ins. wide over all, with a rise of 10 ft. 9 ins., and a length of 17 ft. 3 ins.. Under each foot was a longitudinal plate girder bearing on iron rollers, running on longitudinal timbers laid on the surface of the excavation. The shield was driven ahead by six hydraulic jacks, and in sandy earth it advanced about 23 ft. per day. The jacks were under the roof girders, and the thrust was taken by a series of steel frames used for the arch centering, the roof masonry receiving no thrust. In some places the roof of the tunnel was only 1 ft. 4 ins. to 2 ft. below the surface of the roadway of the Boulevard National, with a heavy traffic and a



A Continuous Dry Kiln for Wood Pulp, Cellulose, Leather, etc.

double track street railway operated by 16-ton steam motors. About 6,189 ft. of tunnel were driven by this method. This shield was described in our issue of July 9, 1896, and it was pointed out that its successful operation was no doubt largely due to its heavy and rigid construction.

A NORWEGIAN DRY KILN FOR WOOD PULP.

The time and expense involved in suitably drying wood pulp, leather, etc., constitute very important items in the production of these materials, and the dry kiln illustrated herewith, which has been very extensively used in Europe, and comes to us well recommended by a European engineer familiar with its work, may prove of interest to American manufacturers. This kiln is the invention of Mr. F. Hiorth, President of the Koaerner Iron Works, of Christiana, Norway, and besides the drying of wood pulp, for which it was primarily designed, is easily adapted to the drying or smoking of fruits, fish, leather, cotton, wool, wood peat and various similar substances. Our informant, Mr. Conrad Skarstedt, Mechanical Engineer, of Chicago, Ill., states that the kiln is patented in this and European countries, and has been most extensively used in the Scandinavian countries of Europe for drying wood pulp.

The engraving shows a longitudinal section of the kiln, which is built entirely of iron and brick in the shape of a rectangular tower, which is divided into two chambers by a partition wall B. Two chain sheaves, C^1, are placed at the top, and two, C^2, at the bottom of the tower, over which run two endless long linked chains, d and e. These chains are guided from top to bottom by channel bars fastened to the brick walls of the tower. The sheaves at the top are driven by gearing from a shaft driven from the outside, but the bottom sheaves simply hang in the loops of the chains. The chains are provided with holes or taps, so arranged that they catch into hooks on the carriers C, and hold the carrier suspended during its journey. The slow movement of the chain thus enables the carriers to be run into position at the bottom of the tower on the upgoing side, hooked to it, carried through the prescribed journey, and finally unhooked at the bottom of the opposite side. No stopping of the machinery is necessary during the manoeuvre, the doors open automatically when the carriers come down on the rails at the discharge side, and these rails having a descending grade outwards, the carrier and load at once roll out of the way of the next descending carrier. When the carrier reaches the outside the doors close automatically, and are reopened only when the next carrier is ready for delivery. On the charging side the movements are also automatic and similar in operation, but are, of course, in a reverse direction.

The time required from the loading to the discharging of a carrier can be varied to suit the circumstances by varying the speed of the chains, but for thoroughly drying wood pulp it is generally about five hours. As will be noticed, the travel of the carriers and the hot air current is opposite in direction, thus securing the so-called principle of cross-current drying. The air is heated either by a steam pipe coil or by a hot air furnace the latter method being used by the inventor, who has designed a special furnace free from sparks and excessive heat, which might cause a fire risk. As a further protection against fire, iron doors, with fusible metal hangers, are provided to close all openings automatically when the temperature approaches a dangerous height. The admission of the hot air from the heater is also controlled by dampers. To secure the proper circulation of the air an exhaust fan is placed at E. According to tests made by the manufacturers, the consumption of coal is about 400 lbs. per ton of dry pulp, and the consumption of power is very small, as the weight to be raised is simply the difference between the weight of the wet material on one side and the dry material on the other.

RECENT NOTES ON SUBTERRANEAN TEMPERATURES.

Early in 1891 the Wheeling Development Co. finished a deep well on Bogg's Run, near Wheeling, W. Va. This well is 4,500 ft. deep, 4⅞ ins. diameter, cased only to 1,570 ft., and it is dry. The strata through which it is drilled is nearly in situ, undistorted and dips only about 50 ft. to the mile. Under these unusually favorable geological conditions careful observations have been here made to ascertain the rate at which the earth's temperature increases as the crust is penetrated, and these notes have been published from time to time. The latest contribution on this head is a paper by Mr. W. Hallock, in the "School of Mines Quarterly," from which the following abstract is made.

As the well was dry, ordinary U. S. Signal Service maximum thermometers were employed. They were lowered and raised and the depth was measured by steel wire. Special tests showed that no precautions were needed on account of air circulation. Observations were made at irregular intervals, and the following table of results is given:

Depth feet.	Temp. Fahr. deg.	Depth feet.	Temp. Fahr. deg.
1350	68.75	3125	80.40
1591	70.15	3232	80.75
1592	70.25	3375	92.10
1745	71.70	3482	93.60
1835	72.80	3625	96.10
2125	76.25	3730	97.55
2256	77.40	3875	100.05
2375	79.20	3980	101.75
2486	80.50	4125	104.10
2625	82.20	4200	105.55
2740	83.65	4375	108.40
2875	85.45	4462	110.15
2990	86.60		
		100	51.30

When plotted, these observations show a slow increase of about 1° F. for 80 to 90 ft., for the upper half of the uncased portion, while the lower part shows a more rapid rate of about 1° F. in 60 ft., with a slight deflection in the regular curve at 2,900 to 3,000 ft., where oil sand occurs. The rest of the hole is practically all in shale. The increase in rate as the bottom is approached must be only temporary, otherwise we would have an improbably high temperature at a comparatively slight depth. Two distinct sets of observations, of which the figures in the table are an average, nowhere disagree more than 0.3° F.

The following table compares these results with observations made at four other great wells:

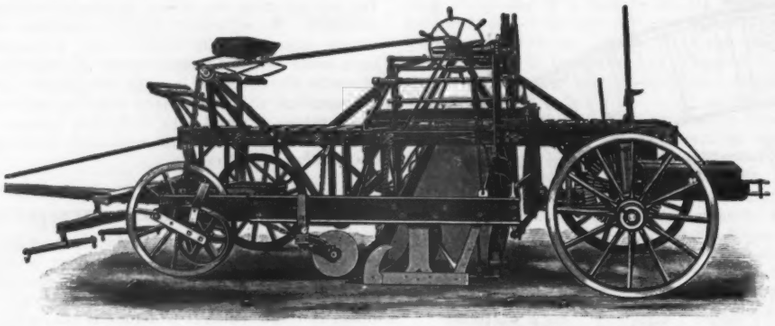
Location of well.	Feet for 1° Fahr.	Total depth, ft.	Temp. at top, Fahr.	Temp. at bottom, Fahr.
Sperenberg, near Berlin	59.2	4,170	47.8°	118.6°
Schladabach, near Leipsig	65	5,740	51.9°	135.5°
Wheeling Co.; top and greatest depth	74.3	4,500	51.3°	110.3°
Mean of lower 3,000 ft.	75.4	....	....	....
Pittsburg; Peters Creek	71.5*	5,386	51.°†	120.9°°

*To 5,000 ft.

When the observations of 1891 were finished the casing was securely plugged and the hole protected. In July, 1893, the hole was opened and found to be full of fresh water up to within 40 ft. of the top. It is supposed that this water entered at the foot of the casing, 1,570 ft. from the top. To test the temperatures with the water in the wells, the ordinary Signal Service mercurial maxi-

mum thermometers were again used, but sealed in a glass tube to protect them from water pressure. Two thermometers were placed in an iron bucket, 3 ft. long by 3 ins. diameter, and two more were in an open wire frame 260 ft. from the end of the wire. There was an obstruction at the depth of 3,200 ft., but above that point the observations in no case showed a difference of 0.2° F. from those taken in 1891 in a dry hole.

The well of the Forest Oil Co., on Peter's Creek, near Pittsburg, which is referred to in the list of deep wells above, is still being sunk and is already the deepest well on this continent. This well is drilled with a cable and is dry, with an inlet of gas at a depth of 2,285 ft. It is on Peter's Creek, about 12 miles S. S. E. of Pittsburg. The temperature observations made at this well by Mr. Hallock are given in the second table, and a comparison of the records of the two wells show that the temperatures at the Wheeling and Pittsburg wells are almost identical for the same depths. The deepest well in the world is that at Paruschowitz, near Reibrick, in Eastern Silesia. This well was over 6,500 ft. deep two years ago and it is proposed to sink it to 8,800 ft. Temperature observations are not to be made, however, until the well is finished.



STEEL EXCAVATING AND WAGON LOADING MACHINE FOR EARTH EXCAVATION.
Western Wheeled Scraper Co., Aurora, Ill., Builders.

A NEW STEEL EXCAVATING AND WAGON LOADING MACHINE.

The advantages offered by a combined excavating and loading machine, or elevating grader, as this form of excavator is commonly called, for certain kinds of earth excavation, have been proved pretty conclusively during the past few years. On the earth sections of the Chicago Drainage Canal excavators of this type were used quite extensively for removing the top 4 or 5 ft. of prairie soil, and showed an average output of from 475 cu. yds. to 500 cu. yds. per ten-hour day. Similar good results with the elevating grader have been experienced in irrigation channel and ditch work throughout the Western states, where the nature of the soil and the character of the excavation permitted the machine to develop its best qualities. The increased use of elevating graders which has naturally followed from these experiences has led to much more attention being paid to strength and durability, and in the accompanying cut we illustrate a grader especially designed to do heavy digging in difficult soil without breakage.

This machine is built by the Western Wheeled Scraper Co., of Aurora, Ill., and is chiefly notable for the use of steel shapes in all of the parts subjected to heavy strain in operation. The main frame, plow beam and elevator frame and supports are made entirely of steel channels and angles. Two channels bolted together back to back form the plow beam to which the plow proper is rigidly attached. This plow beam can be manipulated by the operator so as to vary its vertical and transverse adjustment, and further, can be tilted so as to bring the point perpendicular to the surface of the ground in side hill work. Longitudinal adjustment of the plow can be secured by removing the fastenings and attaching the plow in a new position, but it is not possible from the operator's platform, as the other adjustments are. The illustration shows quite clearly how these several adjustments are accomplished.

Especially important points in the practical operation of the elevating grader are the regular operation and convenience of adjustment of the elevator frame. This frame has to be raised and lowered frequently to meet the different heights of wagon boxes, due to inequalities of the ground or to the construction of the wagon, and the tension of the conveyor belt has to be kept uniform during all these movements. In the machine illustrated the outer end of the elevator frame is attached by two chains converging to the top of an inverted V-shaped mast hinged to the main frame. From the top of this mast a chain passes to and around a horizontal drum. By winding the chain, therefore, the mast is swung back and the elevator frame raised by an equal pull on each side, so that twisting is not possible. With the older method of connecting the two chains holding the elevator frame direct to the drum, it was more or less difficult to prevent unequal winding and consequently twisting of the conveyor frame. In the machine illustrated the conveyor belt passes over rollers smaller in diameter at the center than at the end, giving it a trough shape, and its tension can be adjusted from the operator's platform. From this operator's platform the belt can also be thrown into or out of operation, and all the various adjustments of the plow and elevator can be secured without stopping the machine.

This grader is operated by from four to eight horses, according to the material being excavated, and loads into wagons which are driven alongside of the machine, so that their boxes receive the material from the discharge end of the conveyor belt. The number of wagons required will vary with the length of haul and the difficulty of excavation, but it should always be large enough to keep the grader working to its full capacity. This involves some carefulness of management and in the use of these graders on the Chicago Drainage Canal it was found that the economy of excavation could be materially reduced by having either too few or too many wagons or by careless regulation of the supply.

THE HARDIE COMPRESSED AIR LOCOMOTIVE FOR THE MANHATTAN ELEVATED RY.

Compressed air has for many years been in limited use as a motive power for small locomotives and motor cars for mine work and in street railway service; but the last two or three years has witnessed a revival of interest in this form of motive power on the part of inventors and investors, which is resulting in a more extended trial of this class of motor than has ever before been given to it. The chief difference between the recent work in compressed air locomotion, and that which was done in former years is the use of a very much higher pressure in the storage tanks, roughly about 2,000 lbs. per sq. in., against some 300 lbs. to 600 lbs. in the older experiments. The result is, of course, the storage of a much larger amount of power in the same bulk, which means that a motor car with air storage tanks of a given size can run a much longer distance between chargings than was formerly the case.

What is doubtless the most ambitious attempt at compressed air locomotion for railway service that has ever been made is the construction of a compressed air locomotive for the Manhattan Elevated Ry. in New York city.

This locomotive was built by the New York Locomotive Works, of Rome, N. Y., to the designs of the inventor, Mr. Robert Hardie, Chief Engineer of the General Compressed Air Co., and it is being operated by the American Air Power Co., of New York. We are indebted to Mr. E. E. Pettee, Chief Engineer of the latter company, for the photograph and drawings of the engine from which our illustrations are prepared. It is true that a Hardie engine was tried on the Second Ave. line of the elevated railways in 1881, but at that time the storage pressure was only 600 lbs. per sq. in., while in the new engine a pressure of 2,400 lbs. is made practicable by employing Mannesmann rolled steel tubes for the air reservoir.

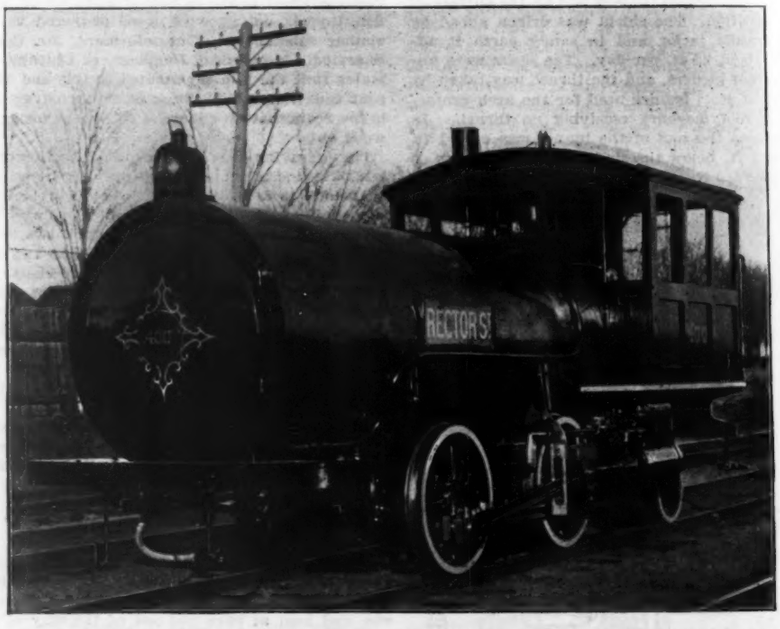


FIG. 1.—HARDIE COMPRESSED AIR LOCOMOTIVE FOR THE MANHATTAN ELEVATED RAILWAY.
American Air Power Co., Owners; New York Locomotive Works, Builders.

As will be seen by the general view in Fig. 1, the new engine somewhat resembles the steam locomotives of the elevated railways, but it has neither smokestack, tank nor coal bunker, and has

a two-wheel instead of a four-wheel trailing truck, and the cylinders are placed under the cab. The air reservoir, which occupies the place of the boiler of a steam locomotive, consists of a set of 27 Mannesmann rolled steel tubes, 9 ins. diameter and 15 ft. 6 ins. long, all enclosed in an ordinary boiler jacket. The drawings show 37 tubes, but the engine, as actually built, has only 27 tubes. The nipples on the front ends of these tubes are fitted with pipes, each set of pipes being connected to a main pipe leading to a vertical header, from the base of which two pipes lead to the pressure-reducing valves, which reduce the pressure to 150 lbs. per sq. in. From these valves the air passes to a vertical reheater in the cab, having a capacity of about 50 gallons of water, which is heated by a small stove at the bottom. The air then passes to the cylinders. The slide valves are operated by a Stephenson link motion, with a Meyer adjustable cut-off, operated from the crosshead. The cut-off may be set at from one-tenth to half-stroke by means of a hand-wheel in the cab, connecting with the admission valve. In starting, it is not necessary to alter the position of the cut-off valve, as a by-pass valve can be opened to effect a connection between the low-pressure receiver and the cylinders, the air entering by the small pipes shown on the valve chest. This valve is opened by pushing the brake handle beyond the point at which it releases the brakes, and as soon as this is done the throttle valve is opened and the engine has ample starting power, regardless of the position of the cut-off. Increased pressure for starting may be obtained by pushing the brake handle still farther forward, thus operating a device on the reducing valve and allowing air to enter the cylinders at a pressure one-third greater than the normal working pressure. When the engine has fairly started, the brake handle is moved back to its running position, leaving the engine to work under normal conditions.

A special air-brake is used for the driving wheels, and the Eames vacuum brake on the train will be operated, as at present, except that the ejector will operate by an air jet instead of a steam jet. The locomotive is designed for a maximum train load of about 130 tons, and the highest recorded speed is 45 miles per hour.

The compressing plant is situated at 100 Greenwich St., near Rector St., and is operated by a 230-HP. Corliss engine, built at the Cooper Works, Mount Vernon, O., and having cylinders 16 × 36 ins. This engine drives a quadruple air compressor built by the Ingersoll-Sergeant Drill Co., of New York city, having cylinders 3, 7, 9 and 21¼ ins. diameter and 36 ins. stroke, and being capable of delivering 500 cu. ft. of free air per minute, compressed to a pressure of 2,500 lbs. The storage reservoir consists of a nest of Mannesmann rolled steel tubes, with a capacity of 820 cu. ft., in which the air is stored at a pressure of 2,550 lbs. The locomotive is charged by means of a self-packing, flexible metallic connection, the time occupied in charging being about 1 minute.

The general dimensions of the locomotive are as follows:

Driving wheels, diameter	3 ft. 6 ins.
Journals, driving axles (hollow), diameter	5¾ "
" truck axles, diameter	4 "
Wheelbase, driving	6 ft. 0 "
" total	13 " 6 "
Truck pin to c. of leading driving axle	7 ft. 6 ins.
Weight in working order:	
On driving wheels	36,000 lbs.
On truck wheels	11,000 "
Total	47,000 "
Cylinders	13 × 20 ins.
" distance, c. to c.	4 ft. 8 "
Piston rod, diameter	2¾ "
Crosshead and guides	Single bar.
Valve gear	Stephenson; Meyer cut-off.
Inlet ports	1 × 12 ins.
Exhaust ports	1 × 12 "
Slide valves, lap, 1-16-in.; lead	¼-in.
" " maximum travel	3 ins.
Air reservoir, Mannesmann tubes	Steel.
" number of tubes	27
" diameter of tubes (outside)	9 ins.
" " " (inside)	8½ "
" length of tubes	15 ft. 6 "
Reservoir pressure, with fresh charge	2,400 lbs.
" when requiring to be recharged	450 "
Cylinder pressure, initial	150 "

Street cars on the Hardie system have been in operation for some time on 125th St., New York city, as noted in our issue of Jan. 14, 1897. It may also be appropriate to note that a detailed description of the latest types of steam locomotives on the New York elevated railways was published in our issue of Feb. 15, 1894.

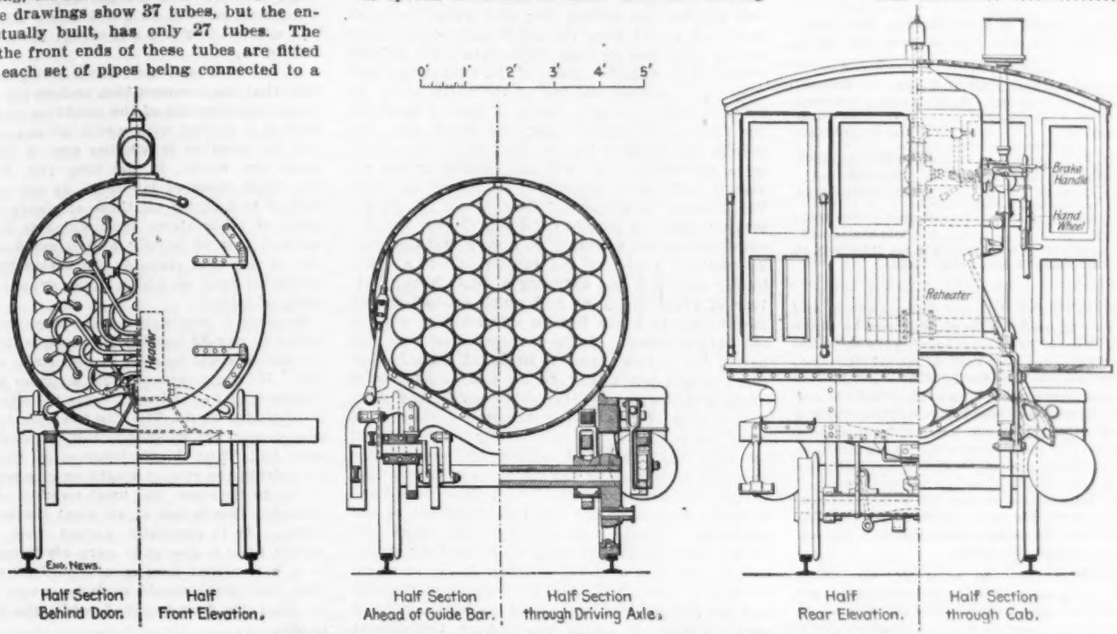


FIG. 2.—CROSS SECTIONS AND END ELEVATIONS OF COMPRESSED AIR LOCOMOTIVE.

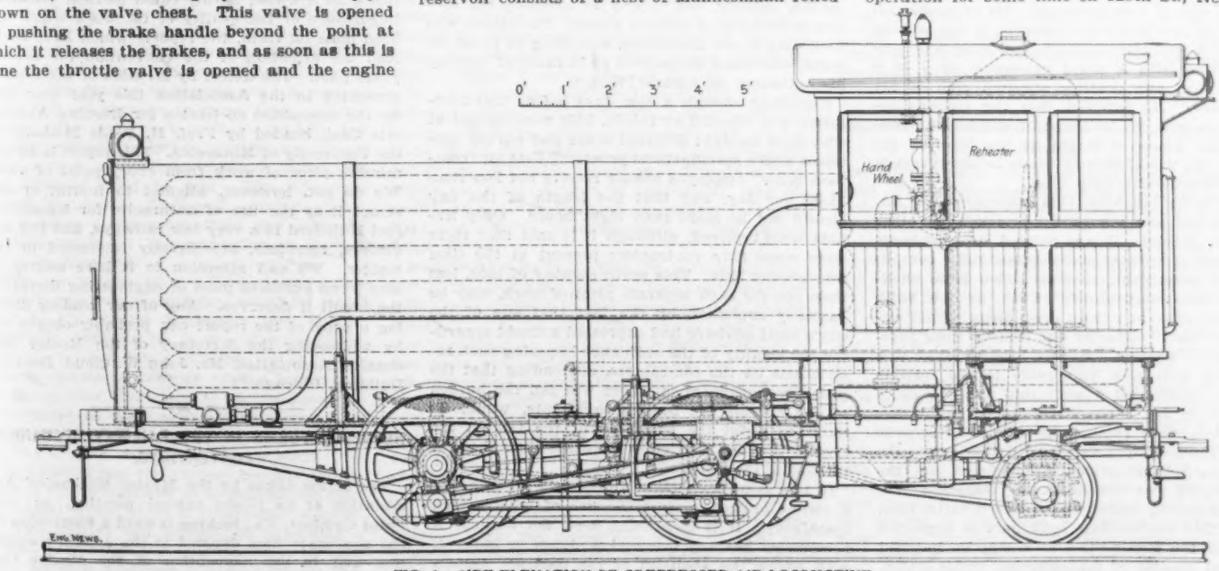


FIG. 3.—SIDE ELEVATION OF COMPRESSED AIR LOCOMOTIVE.

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The long-contested battle between armor and guns, in the navies of the world, having been fought practically to a standstill, some naval authorities are now discussing the comparative efficiency and usefulness of battle ships and torpedo vessels, with the view of ascertaining, if possible, which one of these two types is most likely to survive in naval warfare. In a paper lately read before the United Service Institution, Admiral Colomb, a high authority in the British Navy, took the position that the battle ship of the present day is so nearly perfected that no material improvement is possible; and that we must now look for some entirely new type of warship, under the law of evolution that perfection in any type is a sign of disappearance. He expected this new type in the future development of the torpedo vessel; in a perfectly armored, sea-going and seakeeping ship with a speed exceeding by 7 or 8 knots that of any possible armored ship of the present day. He believed that the torpedo destroyer was now the battle ship; and he was convinced that whatever might be the form of the new type we would shortly cease to build vessels of the present battle ship type.

As might be expected, this assumption of Admiral Colomb was vigorously attacked by other naval men present. It was pointed out that boats of the destroyer class were exceedingly complicated and very liable to destruction from shell-fire; that they were unsafe at sea, as now built, and to put efficient armor upon them would entirely alter their character and destroy their present value in warfare. It was believed that if a battle ship were now vulnerable to the torpedo boat, the smaller and weaker ship was still more vulnerable to the rapid-fire guns of the larger vessel. According to the opposition, the torpedo boat and the destroyer were useful adjuncts to the battle ship, both in attack and defence, but the torpedo vessel was not likely to supplant the larger and heavily armed and armored battle ship.

But in this controversy both parties neglected to consider the possibilities of a torpedo handled by a vessel capable of manoeuvring under water. If the submarine boat, of the Holland and other types, should ever be developed to the extent that now seems to be perfectly feasible and possible, the enormously costly battle ship will indeed be little more valuable than what its material would bring as scrap. Mere commercial considerations would forbid the expenditure of millions upon a vessel that was susceptible of attack by a swarm of comparatively inexpensive submarine torpedo boats, and would surely be destroyed by some one of them. Rapid-fire guns would be useless against the hidden foe; and while the swift destroyer might keep the other boat under water longer than was perhaps comfortable, this defence would be of negative value if the submarine boat meanwhile reached the hull of the battle ship. So long, therefore, as both classes of ships keep above the surfece we believe that the battle ship has certain advantages; but let the torpedo be carried by a submarine boat and the conditions are reversed, and battle ships will no longer be built. The coming "battle ship," then, is not of the destroyer class, as Admiral Colomb claims, but her substitute would probably be a very fast and easily-handled vessel of the cruiser type; a ship lightly armored, but carrying a fairly heavy battery of rapid-fire guns and quick enough in her movements to make her an uncertain target for submarine attack. Such a vessel would be still useful for certain purposes in naval warfare, but there would practically be an end to successful naval attack upon well-protected ports. Any guns that a ship of this lightly armored cruiser class could carry would be enormously over-matched by land batteries, and attack by battle ships would be forbidden by the certainty of destruction by the submarine torpedo. Under these conditions it would seem that the fuller development of the submarine torpedo boat would be the most effective instrument that could be devised for securing the peace of nations; at least, so far as naval warfare is concerned. And the success of Holland and his fellow inventors would doubtless mean a vast economy in naval expenditure throughout the world.

The cost and character of municipal works in the future will depend somewhat upon the outcome of no little agitation now in progress here and there throughout the country regarding the relative advantages of the contract system and the day labor system of doing city work. The mayor's cabinet of Toledo recently passed a resolution in favor of the day labor system, as follows:

> The present system of doing the public work of the city by contract to the lowest bidder, without limitation as to the question of wages, is destructive of the foundation of our civic life, and ought to be superseded by a system that will admit of doing the work of improvement by day labor.

In the discussion at the time the resolution was adopted, Mayor Jones, who introduced it, said it was not intended to do away with the contract system entirely, but merely to condemn the system in so far as it reduces wages. The others who took part in the discussion, according to press reports, expressed themselves as in favor of entirely discontinuing the contract system.

Curiously enough a few days before this resolution was adopted at Toledo, bids were opened at Cleveland on eight different sewer and paving contracts under specifications providing that all "common labor" employed should receive not less than $1.50 per day, and that the length of the day should not be more than eight hours. Only five bids were received, although it is said that there were some fifty contractors present at the time for opening bids. This small number of bids, less than one for each separate piece of work, may be partially explained by the fact that one of the city's legal advisers had expressed a doubt regarding the legality of the ordinance imposing such restrictions on the contractors, contending that the property-owners, upon whom will fall the burden of the special tax for improvements, would be likely to resist the collection of the tax on the ground that the restriction increases their share of the cost of the work.

In this same connection it is of interest to notice a recent protest against the use of labor-saving machinery. It is mentioned here, not because it necessarily has any connection, direct or indirect, with either the abolition of the contract system or a compusory minimum wage rate to be paid by contractors for city work, but because it illustrates the extreme, we may hope, of the various plans propounded from time to time for the amelioration of labor. This protest came in the shape of a resolution introduced in the common council of the city of Philadelphia early this month.

The resolution provided that the Director of Public Works be requested to restrict as much as possible the use of labor-saving machinery on all work done by and for the city of Philadelphia. The press reports do not indicate that this idea was approved by any one except the man who advanced it.

As one studies these various incidents, it will be seen that the common idea underlying all of them is the improvement of the condition of the laborer. This is a motive with which all can sympathize; but the question is whether any of these various plans are really, in the long run, beneficial to the whole mass of laborers. Is not one common fallacy underlying all these attempts to raise the price of labor above that which is fixed by the natural law of supply and demand—the fallacy that a city or a state, or the nation itself, has an unlimited fund on which it can draw for the payment of labor?

Suppose a contractor doing city work is compelled to pay $2 per day for work which plenty of workmen would be glad to undertake at $1.50 per day. He must evidently bid a higher price on his contract, and so the work costs the city more than it otherwise would. The city has then just so much less money left to spend than it would otherwise have had. Thus the tendency of all these schemes for raising the rate of wages on city work appears to be to decrease the total number of men employed. This is not at all what the labor leaders desire. It is generally agreed that everybody should have a chance to earn his living, and that it is better that four men should all be at work than that three should work for wages amounting to what the four received, while the fourth man is idle.

Another point may be briefly touched on here. Those who are working for better social and economic conditions are looking largely to an extension of the functions of the modern city government; but if business carried on by municipalities is to be hampered by restrictions as to rates of wages, which do not exist in private work, a strong argument is placed in the hands of those who contend that all of the business of supplying cities with light, water, sewerage, transportation, etc., with the profits incident thereto, should be left in the hands of private companies.

We present in this issue a full report of the proceedings of the annual convention of the Master Mechanics' Association held last week at Cape May. The committee reports presented this year, taken as a whole, hardly equal in their technical importance or the quality of the work which has been done on them, the reports which have occupied the attention of the convention for several years past. The ablest by all odds of the reports presented to the Association this year was that by the committee on Grates for Burning Anthracite Coal, headed by Prof. H. Wade Hibbard, of the University of Minnesota. This report is an admirable piece of work from every point of view. We do not, however, attempt to reprint or abstract it as the use of anthracite for locomotive fuel is limited to a very few railways, and few engineers, therefore, are directly interested in the matter. We call attention to it here merely to give to an excellent piece of engineering literature the credit it deserves. Any of our readers desiring a copy of the report can probably obtain one by addressing the Secretary of the Master Mechanics' Association, Mr. John W. Cloud, Rookery Building, Chicago.

NEEDED REFORMS IN THE RAILWAY MECHANICAL CONVENTIONS.

The action taken by the Master Mechanics' Association at its recent annual meeting, at Old Point Comfort, Va., looking toward a shortening of the aggregate time devoted to the annual convention and to the convention of the Master Car Builders' Association, promises to bring about a badly needed reform. For some eight years an arrangement has been in force by which these two associations have chosen the same place of meeting; the Master Car Builders have begun

their sessions on a Tuesday, and the other Association has convened on the following Monday. This year, for some reason, the Master Mechanics' opening session was not held till Tuesday, but this delay has served a good purpose in calling general attention to the waste of valuable time which takes place under the present arrangement. Many railway mechanical officers are members of and attend the sessions of both Associations. But to do so means the sacrifice of a solid two weeks of time, when the travel to and from the place of meeting is included. Many railway officers who would like to attend both conventions feel unable to take so long a time away from their regular duties.

Further than this, the long convention period is said to be becoming a subject of complaint by the General Managers and other superior officers. This last reason admittedly had much to do with the formal action taken by the Master Mechanics' Association. Briefly stated, this action was to instruct the Executive Committee in making the arrangements for the 1898 convention to confer with a similar committee of the Master Car Builders' Association with the view of having the entire work of the two conventions completed in a single week.

It is interesting in this connection to recall the jealousy which formerly kept these two Associations a long way apart. The proposal that the two Associations should select each year a common meeting place was by no means heartily approved by all the members when it was first adopted. But this jealousy has practically disappeared. Last year the two Associations even chose a common executive officer; and the hearty approval which greeted the proposition made in the Master Mechanics' Association this year to bring the times of meeting closer together is good evidence that a further co-operation between the Associations in their work will meet no opposition.

The first plan proposed for the time devoted to these conventions is that a joint opening session be held by the two Associations and that afterwards the work of each Association be carried on separately. It has also been suggested that one Association could hold sessions in the forenoon and the other in the afternoon of each day. Probably some of the older members who still hold to the idea that the convention is merely a sort of summer holiday affair, would object to such a plan as imposing too much work upon the members who attend both conventions. But two sessions a day would be no greater amount of work than the members are accustomed to do at their offices, or at least those of the members who are accustomed to attend both conventions.

If, however, this plan be objected to, there is no reason why the first three days of the week might not be given to one convention, and the next three to the following one. This year the Master Car Builders were in session 18 hours, distributed over four days. The Master Mechanics were in session 15 hours, and got through in three days. Either could have done their work in three days in this or any year without a particle of difficulty. If an unusual amount of business made it necessary, evening sessions could be held. The American Society of Mechanical Engineers always holds evening sessions at its conventions and is by no means remarkable for the proportion of time it devotes to work, either.

Possibly one reason why a long convention period has been accepted without protest by many members of the Master Mechanics' and Master Car Builders' Associations is the elaborate programme of entertainment provided for them by the representatives of railway supply houses. It is safe to say that this class of entertainment is far more lavish at these conventions than at the annual meetings of any similar railway organization or engineering society in the country. So firmly established has the custom become and so elaborate is the programme to be carried out that a quite formal organization of supplymen is maintained, with officers and committees appointed a year ahead to arrange for entertaining each convention. There is doubtless a valid business reason for such an organization to arrange for the exhibition of car and locomotive fittings and appliances at these conventions, and there is no doubt that the presence of these exhibits and the meeting of manufacturers and railway men to examine and discuss them in an informal way are mutually beneficial. The supplymen's organization assumes quite a different aspect, however, when it undertakes the collection and expenditure of from $5,000 to $7,000 additional which is raised by taxing the exhibitors and which is spent for excursions, concerts, balls, flowers, candy, music, carriages, etc. The most valid defence for this custom which has ever been made is that it is an improvement on the practice which preceded it, when every supply firm "went on its own hook," and strove to outdo every other in the lavish splendor and entertainment which its agents tendered to the members of the Associations.

But the truth is that the entertainment by the Supplymen's Association has by no means superseded the giving of private entertainment. In fact, with a large number of the firms represented at these conventions, the contribution of $50 to the general fund of the Supplymen's Association is a mere trifle compared with the total expenditures which their attendance upon these conventions involves.

We do not doubt that already many of the heads of railway supply houses, as they examine the bills from Old Point Comfort, and contrast them with the current accounts of sales of goods to railway companies and the dearth of cash receipts from bills of goods already sold, are seriously asking the question: "In these times, does it pay?" It is quite probable that the total expenditure which railway supply houses will have to meet on account of the Old Point Comfort convention will not fall short of $75,000 to $100,000. Is it a good investment? Will the favor of the Master Mechanics and Master Car Builders, which this is all spent to gain, be worth this amount in cash to the vendors of railway supplies? If this is the case, it might be appropriate to ask whether favor or merit counts for most in the purchase of railway supplies. We fully believe that a very great proportion of the active members of the Car Builders' and Master Mechanics' Associations are entirely honest and conscientious in the discharge of their duties; but they certainly must be aware of the fact that it is not from love that the railway supply houses send their representatives to furnish lavish entertainment at these conventions. If they spend a hundred thousand or so in cold cash, it is solely because they expect to get at least that much from the railway companies which they would not have received had they not made this expenditure.

We believe, as we have said above, that this is a mistaken policy, and that merit and low price are the things which count in the purchase of railway supplies; but outsiders do not know this. The members of the Master Car Builders' and Master Mechanics' Associations must appreciate the fact that they cannot accept these lavish entertainments without a certain loss of dignity.

It is not strange that the General Manager who hears something of the amount of champagne and cigars which are being consumed at the conventions which the heads of his mechanical departments are attending, should have a certain scepticism as to the wisdom of sanctioning long absences at such conventions, no matter how brilliant and able the technical work at the convention may be.

A suggestion for improving the work of the Master Car Builders' Association at its annual meetings, which was received by the members with considerable favor at the Old Point Comfort convention, was contained in the closing recommendation of the committee appointed to select the subjects for committee investigations and reports at the convention of 1898. This was, in brief, that instead of following strictly the time-honored custom of appointing a committee of from three to six members to report upon each question, some of them should be made the subject of individual investigation and of individual papers by different members of the association. As is well known by those familiar with the committee work of this and kindred railway technical associations, the bulk of the labor falls upon the chairman of the committee, and in many cases the report presented is entirely his production, more or less modified or perhaps carelessly approved by the remaining members of the committee. This is neither an actual joint production of the several members comprising the committee, nor is it the unrestricted opinion of the chairman. Of course there have been cases in which these reports were the result of joint committee work in the truest sense, but these are comparatively few in number. It will probably not be desirable to abandon the practice of committee reports entirely, especially when it comes to dealing with designs and constructions which the Associations may desire to adopt as recommended or standard practice. But even with these questions it will ensure more careful and deliberate action if they be made the subject of individual papers first and be then subjected to a competent committee for final recommendations or disapproval. The programme for each convention would then consist partly of individual papers on new subjects and partly of final committee reports on the subjects which had been handled by individual papers the year previous. This will ensure a mature consideration of designs brought before the Associations before their adoption, which is not always the case, under the present arrangement, and, moreover, it would give the committees a fund of fact and opinion from which to commence their studies which the present method of sending out printed circulars of inquiry hardly ever gives. Many other advantages of such a system as has been suggested will appear upon a little thought, and we believe that a decided improvement will result if the suggestion of the Master Car Builders' committee on subjects is adopted.

LETTERS TO THE EDITOR.

Esthetic Design in European Bridges.

Sir: In the article on "Esthetic Design in European Bridges," appearing in your last issue, are a few errors, two of which permit me to correct. The bridge over the Elbe at Loschwitz, in Saxony, is classed in the article as a rigid suspension bridge. It is not a suspension bridge, not even in appearance, at least to the trained eye of the engineer. It is a cantilever bridge, whose two arms are joined in the middle by a hinge.

In describing the two bridges of the double-arch (fish-bellied) type, they are stated to be uneconomical. The contrary is the fact; theoretically and practically, that type is very economical. But the calculation of it being rather difficult and involved, it does not lend itself readily to standard manufacturing, which makes our American bridges so cheap in first cost.

The most interesting feature of the Carl bridge in Prague is not mentioned in the article, namely, that it is over 500 years old, and required 145 years for construction, a longer time probably than any other bridge in the world.

New York, June 18, 1897. A Subscriber.

(The Loschwitz bridge was correctly described as a cantilever on our inset sheet, but the error in the original manuscript, in which it was referred to as a "rigid suspension" structure, was by an oversight not changed.—Ed.)

Concerning the Midford System for Raising Sunken Vessels.

Sir: In an item in the Engineering News of June 10, which relates to the removal by dynamite of the steamer "Ailsa," I regret your unhappy choice of words when you state: "The attempt" (to raise this vessel) "failed for various reasons." Such a statement appearing in the Engineering News would lead one to infer that the editor of that journal believed that the design, method and execution of the work were at fault—the truth being that such was not the case.

Many eminent engineers carefully examined my design and mode of operation and were absolutely satisfied with them, and every engineer who was professionally employed by investigators, made a favorable report. Again, the other members of the Board of Directors of the Midford Pneumatic Salvage Co. (which had the contract for raising the "Ailsa"), publicly stated, after my removal: "The Midford system is all right." But the fact is that my devices and method never were fully carried out. After September 18, innumerable changes were made in the work already finished, and the subsequent work was carried forward on other lines. A first-class engineer, familiar with the questions involved, would have successfully raised the vessel.

The only claim I made which was at all questioned by engineers was the ability to "jet" chains under the vessel, and this had been readily accomplished by me some time prior to September 18, 1896, although the "Ailsa", was sunk in 40 ft. of water and 12 ft. of mud.

The true inwardness of why the Directors of the M. P. S. Co. preferred to "leave the 'Ailsa' forever at the bot-

tom of the sea," rather than to allow me to succeed, is a story which will be fully and explicitly told in due course and under proper conditions.

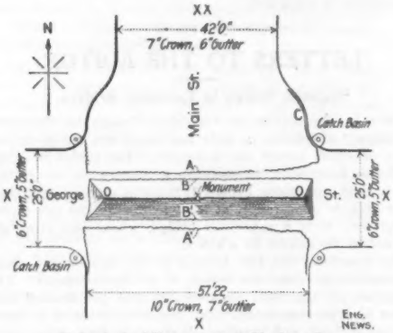
Permit me to state that the Midford system entirely rejects the use of "pontoons" in raising submerged vessels. My system never was tried to the final point of "attempting to raise the 'Ailsa' "—therefore it never "failed."

Yours very truly, A. G. Midford.

Brooklyn, N. Y., June 12, 1897.

Upheaval of Pavement at Street Intersection at Marion, O.

Sir: The accompanying sketch represents the upheaval of Main and George streets block pavement intersection, at Marion, O. The blocks are made of what is known as bastard clay. The filler used was Murphy's patent grout. This intersection was laid early this spring on a foundation of 8 ins. of crushed stone rolled with a 17-ton roller, and upon this the cushion coat of sand 1 in. in depth was laid. The sand composing this layer contained a large percentage of water, some of it being frozen with the sand. The four wings of the intersection, as will be noticed, are of different crowns and gutters, and the curb was set to make the elevation of the center of the three wings marked X about the same, while the point XX was made 0.1 ft. lower than the point X. The upheaval began along the lines A and A^1, and drew the point C away from the curb ½-in.; but the under pressure being not sufficient, the pavement fell and rose along the lines B and B^1, distant 5 ft. on either side of the center, 75 ft. in length, with a rise of 18 ins. at the center line. It formed a perfect hip-roof and could not be excelled in neatness by a mason. The blocks only lost their bond



Upheaval of Pavement at Marion, O.

through the pavement on each side of the center line OO, pulling apart ½-in. The foundation beneath the block appeared the same as when it was first laid, except that the sand and crushed stone were dry. Very intense heat radiated from beneath the block directly after the upheaval.

My theory for this eruption is the accumulation of heat caused from the drying of the cushion coat and the frosted stone from which the foundation was composed, which was so intense that it caused the expansion of the block from beneath.

Please give me your theory for the eruption in this week's Engineering News. Yours truly,

E. S. Ault, C. E.

Marion, O., June 12, 1897.

(It is apparent that the upheaval was caused by expansion, and it was the longitudinal expansion of the pavement along the line of Main St. that was the chief cause of the upheaval, as is shown especially by the pushing of the pavement at C away from the curb. Doubtless the effect of the hot sun on pavement laid in freezing weather with joints solidly filled was a principal cause of the expansion. The incident is a very instructive one, as illustrating the need of making provision for expansion of brick pavements lengthwise of the street as well as across it.—Ed.)

Diagrams for the Relative Strength of Gear Teeth.

Sir: In a marked copy of the Engineering News just received, you state with regard to my "Diagrams for the Relative Strength of Gear Teeth," that they may be of service to those having frequent occasion to design gearing by showing how diagrams may be made from formulas which are assumed to be correct.

It is not clear to me how the diagrams may be made useful in this manner. Will you kindly show, by the use of an example, how such an application can be made without the expenditure of much time and labor, many times as much as needed in applying the diagrams directly to the solution of the problem, without the use of any formula, as they are intended to be? This is not intended to include formulas for determining the pressure at the pitch circle when the rate of power transmission and the velocity of the pitch point of the tooth is known.

The whole object in laying out the diagrams was to give the designer a ready and simple means of designing teeth for strength without the use of any formula. A factor of safety must be used, of course, whose value should depend upon the following conditions: Speed of gear; inaccuracy of alinement and of tooth forms; the presence of foreign substances between the teeth; liability to shocks; and the number of teeth in working contact. In selecting this factor, the designer would naturally be guided by his judgment and such examples of gears in service, as are available and deemed acceptable. Formulas must take into consideration the same data, and therefore it appears that the use of the diagrams to plot formulas would simply be going through an unnecessary piece of work. For any other system of gearing than those for which the diagrams are intended there would have to be another set of diagrams applicable to that system. This also applies with equal force to formulas.

The cause which led to the making of these diagrams was the entirely unsatisfactory and tedious use of gear formulas while teaching students in designing machinery.

I was not present when the paper on these diagrams was discussed before the A. S. M. E., and have not seen any of the discussions. The above remarks clearly cannot apply to anything said there.

Yours truly, Forrest R. Jones.

University of Wisconsin, Madison, Wis., June 7, 1897.

(As we understand Prof. Jones's paper, his diagrams are based primarily upon the ordinary formula for the strength of a cantilever. He assumes that the strength varies as the width of face of the tooth, and as the square of the thickness of the tooth at the section which is weakest, taking no account of the shearing stress, which he considers to have very small effect. From these and other assumptions, concerning which Prof. Jones says in his paper: "there is no desire on the part of the writer to discuss how near or how far away from the truth the assumption made for determining them (the diagrams) may be," he constructs his diagrams. We think, therefore, that the statement made in our report of the Hartford meeting "that they may be of service to those having frequent occasion to design gearing by showing how diagrams may be made from formulas which are assumed to be correct" is quite a proper one, but it might also have been added that the diagrams having thus been made once for all, they will be of service to the designer in proportioning teeth directly from them without the expenditure of the time and labor necessary to proportion them directly from the formula. Two other sets of diagrams for strength of gear teeth, besides those of Prof. Jones, have recently appeared, the first by Mr. Henry Hess, in the "American Machinist," in February last, and the second by Mr. John H. Barr, in the "Sibley Journal of Engineering," for June. Both of these diagrams are based on the formula of Mr. Wilfred Lewis, which Prof. Barr says "is different from and perhaps no better than that of Mr. Jones."—Ed.)

The Ockerson Topographical Symbols Used on Tracing Linen.

Sir: I send you a blue-print of sheet No. 20, Ouachita River, La. The topography, on this and the other sheets, was plotted in pencil on tracing cloth in the field, soundings, elevations and inking being done in the office. The feature of especial interest is that the signs for timber, cotton and willows were printed with the Ockerson printing device.

Until this year no attempts were made in this office to print topographical signs on tracing cloth, since experiments demonstrated that to use printer's ink necessitated either several months for drying, or it was necessary to iron each sheet four or five times under blotters, with due regard to heat, excess of temperature causing permanent blistering of the sheet.

In an article in your issue of Oct. 15, 1896, it was stated that the city engineer of Salt Lake City used a quick-drying ink for printing titles, etc., on his maps. I wrote to him, obtained his method of using the ink, and applied it with the greatest success to printing topographical signs on tracing cloth. This ink is prepared by mixing the best lithographer's ink with Japan-varnish and spirits of turpentine, and it is used in the same way as printer's ink. When the printing on a sheet is completed, the sheet is hung up for five or six hours, when it can be handled with impunity.

In preparing the ink only the best of lithographer's ink, Japan-varnish and spirits of turpentine are used. Take a small piece of ink; for an inking slab 11 × 16-in., a piece about ½-in. diameter is sufficient; place it on the slab, moisten well with Japan-varnish and mix with a knife until of a pasty consistency. Then use the inking roll until the ink is spread evenly over the slab, using all the while spirits of turpentine freely. When ready to print, spray the slab with turpentine until the inking roll will run across it without sticking; this operation to be repeated every time the printing device is re-inked. Avoid getting too much ink on the slab, and trying to re-ink without first spraying the slab with spirits of turpentine. An oiler is best for spraying the turpentine. Fresh ink should be mixed twice a day, removing the old ink from the slab, roller, printing devices, etc., with gasoline.

The masking, cutting out, printing and retouching takes from two to three days per sheet, depending upon the length of river and character of the topography depicted. As in everything else, care and practice and the best results are synonymous. Yours truly,

F. Y. Parker,

U. S. Engineer Office, Vicksburg, Miss., June 4, 1897.

(We can certify that the resultant blueprint work is excellent, clean and sharp in all its details. The apparatus devised by Mr. J. A. Ockerson, M. Am. Soc. C. E., for printing these conventional signs on maps was described in the Transactions of the American Society of Civil Engineers for 1885, and reprinted in Engineering News of Dec. 5, 1885. As some time has elapsed since this publication, the process and apparatus may be briefly described as follows: Drawings are first made of the signs to be used, and from this is cast a copper electrotype shell, backed with ⅛-in. rubber, and this shell is slipped over a wooden roller 4½ ins. diameter by 3 ins. long. This roller has adjustable handles, giving it the appearance of a rolling pin. In using this roller, when inked, masks cut from paper protect the parts which are to be left intact, or marked by other signs; and to protect names, outlines of roads, streams, etc., already on the map, these are rubbed over by a pencil made of common starch, which repels the ink. After the signs are printed the starch is wiped off, leaving the name as clean as before. A sheet covering 900 sq. ins. can be prepared and printed in two days, a work which would require a skillful draftsman at least a month. Mr. Ockerson is now Principal Assistant-Engineer of the Mississippi River Commission, and his address is 2732 Pine St., St. Louis, Mo. He can doubtless inform those interested where the sign-rolls can be obtained.—Ed.)

Some Questions Respecting the Wellington Series Engine.

Sir: For some time the writer has had several questions relative to the Wellington Series Engine, which he has wished to ask, but on account of the severe criticisms of your paper upon the errors and ignorance of others he has refrained from so doing in the hope that some others, more venturesome, would seek the information on the same points.

In the numerical example given on page 211 of your issue of April 8 it is assumed that:

There are five sets of boilers, engines and condensers.

Each set is to do the same amount of work and have the same thermodynamic efficiency.

Temperature of fluid entering first boiler is 500°.

Temperature of fluid leaving last boiler is 220°.

Temperature of fluid leaving cooler is 50°.

Difference in temperature between fluid and steam leaving boiler, 10°.

Difference in temperature between water and fluid leaving condenser, 10°.

Percentage of heat extracted from each engine, 15%.

Can all these quantities be assumed indefinitely? By assuming the last as 10% some of the others are found to interfere.

Immediately following this example it is stated as evident that if water is used as a working substance, the engines having the highest temperatures ("toward the right") "will do a much larger amount of work than those toward the left." This is followed by a number of sentences strongly implying that, with other working substances in some of the engines, these conditions might be altered. The first statement is far from evident to the writer, and the second is indeed a deep mystery. Perhaps he looks at it all in the wrong way. The heat taken out by each engine is in all cases 15% of the heat passing through it, or 15% × 56° × specific heat × rate of flow of the fluid. The only way in which the engine can dispose of the heat is by doing work, by radiation and convection and by external leakage. These last ought to be small compared to the first, and any variations among the three quantities could scarcely be expected to produce great changes in the work done. Again, radiation and external leakage would be greatest with engines with the highest temperatures and pressures; hence, unlike the statement in the article, the lower pressure engines would do the greater amount of work; but, in any case, would not the difference between the amounts of external work be small?

Regarding the advantages to be derived from the use of working substances having lower vaporization tempera-

tures: If the heat extracted from the working substance be the same and the temperature be the same, how can there be any gain in the work done. The radiating surface might be reduced somewhat, but would this lessen the radiation loss sufficiently to make a great gain, as seems to be implied by the paragraph in question. The use of a substance having lower vaporization temperatures to reduce the final temperatures of the system does not seem to be intended, as it is not mentioned, besides the paragraph refers to the numerical example preceding it.

In the paragraph on the details of construction is the suggestion that the engines be made "exact duplicates" of each other. How can this be done? The lower pressure engines would require slightly less weight of working substance but would have to let an enormously greater volume pass through than those of a higher pressure.

There are many other questions about which I desire information, but the foregoing are the most puzzling. I am, Yours truly, R. M. W.

Allentown, Pa., May 20, 1897.

(Answering first our correspondent's opening sentence, we think that he misjudges us when he accuses us of "severely criticising the errors and ignorance of others." Certainly it is our intention to treat with all courtesy and consideration those who write to us to seek or impart information.)

Our correspondent's difficulty in the study of the Wellington engine appears to us to rise partially from a misapprehension of the numerical example which we introduced in the description. We used this merely to illustrate in a very general way the character of the heat transfers which would take place in a series engine of that type, and we did not intend to be understood by any means that these represented the actual quantities which would exist in a working engine. Our correspondent is entirely right in supposing that the various quantities which were assumed as the example are by no means independent of each other; it was only because we intended the example to show the general nature of the process, not actual working quantities and conditions, that our assumptions were allowable.

With reference to the next question of our correspondent, respecting our statement that under the assumed conditions "the engines having the highest temperature will do a much larger amount of work than those toward the left," the original description was somewhat in error in its statement of the case, and we can best set our correspondent straight by a re-statement as follows: With water vapor used as the working substance in all the engines of the series, and with a uniform amount of heat transmitted to each engine, it would be possible to obtain in theory a uniform amount of work from the various engines only by increasing the volume of the cylinders toward the "cold end" of the engine.

But while this is theoretically practicable, the same difficulties which limit present steam engine practice in the expansion of very low pressure steam in cylinders of very large size would be operative here. And for this reason Mr. Wellington proposed to use different working substances in the different engines of the series, so chosen that the engines could be made duplicates of each other and the boiler pressures and condenser pressures would be nearly uniform throughout the series.

By this means it would be possible to make an engine which would work economically under a range of temperature which is practically beyond the power of the triple or quadruple-expansion engine to economically handle, and which would work under a still greater temperature range, whose lower limit would be less than can be employed at all in the ordinary steam engine. In fact it was stated in our original article that the claim made for the Wellington engine is that "it affords a means of converting heat into work by the force of vapor expansion under a greater range of temperature than is possible with any other form of motor."—Ed.)

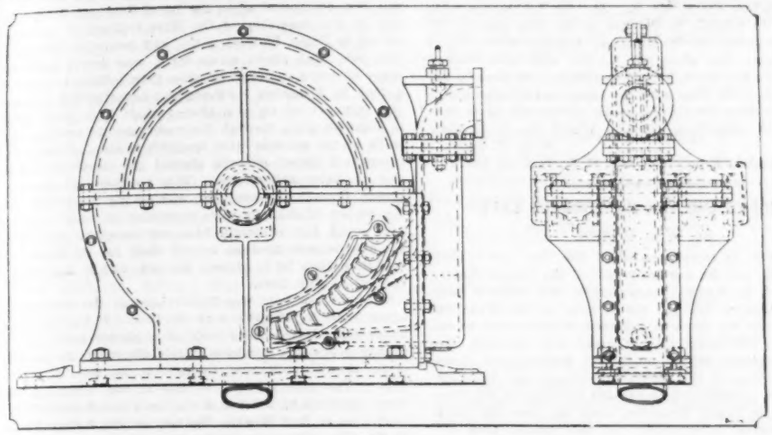


FIG. 1.

The Cazin Impulse Water-Wheel.

Sir: In your issue of May 27, in the article entitled "The Perfect American 'Hurdy-Gurdy,'" there occurs the following expression of editorial opinion: "However we may differ * * * we see no reason to doubt that he (Mr. Cazin) has designed an exceedingly good impulse water-wheel."

Permit me to call attention to a reason for very grave doubt as to the excellence of the Cazin wheel, for which you will have to look no further than the cuts accompanying the article in question.

From Figs. 2 and 4 it is at once seen that the wheel has not a free discharge; that is to say, the water, after completing its work, does not clear the wheel, but is left with no velocity at a point where it must be struck by the bucket next coming into action. Mr. Cazin avoids calling the public attention too directly to this impossible discharge by failing to indicate the discharge in any illustration of several buckets in their proper relative positions (Figs. 1 and 4) cutting off the stream abruptly after entrance.

Now, the power lost in this way is far greater than would be thrown away were the water allowed to leave the wheel with a small residual velocity in a direction at right angles to the line of entrance, sufficient to clear the wheel. To accomplish this there must be given to the bucket a small discharge angle—in other words, the reversion of the jet must be something less than 180°. But this is not in accordance with the "peremptory condition of highest practical efficiency," therefore Mr. Cazin will have none of it, gives his buckets no discharge angle, and puts on the wheel a friction brake of dead water.

Experience shows that a discharge angle of 10° is sufficient for clearance in nearly all cases, and it may be readily shown that this discharge angle involves a loss of efficiency of less than 1%. The loss due to backwater it is hardly possible to calculate, but experience and experiment show it to be very many per cent., even when the discharge but partially interferes. What then must the loss be when the interference is complete? Unfortunately the loss due to obstructed discharge did not appear in his equation for efficiency, therefore Mr. Cazin lost sight of it.

Moreover, the Cazin wheel does not comply with the second "peremptory condition," i. e., "constant inversion," for the reason that such a condition is impossible whatever the form of bucket, and is approached only as the radius of the wheel approaches infinity. This failure is even shown in the illustration, Fig. 4. But Mr. Cazin endeavors to minimize this alteration of entrance angle by putting onto his wheel twice as many buckets as necessary, thus doubling two losses already great enough—friction and entrance disturbance. Evidently another factor—friction—did not appear in his equation for efficiency.

In fine, Mr. Cazin has but added to the large number already on the shelves of the Patent Office, another bucket model, which exemplifies the pursuit of the unattainable on a single idea with sole reliance upon theory and mathematics, leaving out of count all practical results. And now, it may be apparent to Mr. Cazin, as it has long been to the public, why "Pelton stopped half-way" with reversion of the stream. Nevertheless, the designers of the Pelton wheel did not stop until they had put wheels upon the market giving commercial efficiencies of from 85 to 93%.

If, now, the unavoidable friction of bearings and fanning of the air be taken from 100% and the difference subtracted from the result, the remainder will be so small as to make it evident that in endeavoring to improve the Pelton bucket Mr. Cazin is wasting his time and the promoters of the scheme are wasting their money.

Dorville Libby, Jr.

3144 21st St., San Francisco, Cal., June 7, 1897.

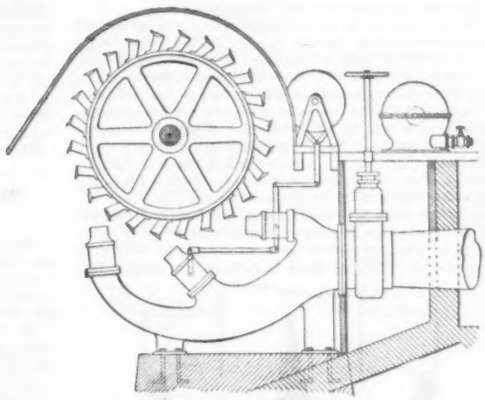


FIG. 3.

(We submitted a proof of the above letter to the American Impulse Wheel Co., and append the reply sent us as follows:—Ed.)

Sir: No progressive step in technical industry has ever been permitted to enter on its path of success without finding opposition on the part of those who consider their interest damaged by such step.

If such natural opposition appears, in the matter of the Cazin power wheel, of no more serious character than the preceding letter, neither patentee nor promoters of the Cazin wheel find cause for even the mildest complaint. It might pass without being noticed, were it not that silence might be wrongly interpreted as assent.

A Mr. Dorville Libby, of San Francisco, constituting himself the champion of the Pelton wheel, has leveled a literary lance at the undersigned, who feels confident of presently exercising the same function on Mr. L.'s lance that was exercised by a windmill on the lance of a gentleman of equally romantic propensities.

Mr. L. claims the existence of "a reason for very grave doubt as to the excellence of the Cazin wheel," and this reason he finds in "the cuts" representing the Cazin wheel. Of what "the cuts" show he bases his statements "that the wheel has not a free discharge," that "the water does not clear the wheel."

Had Mr. L., Jr., been contented with this explanation about his individual conception of what the cuts of the Cazin wheel indicate, he would not involuntarily have paid the Cazin wheel so just a compliment as the following:

"The water is left with no velocity."

Mr. L. thereby admits that the water that leaves the Cazin vanes has no other motion, except such as will be again and anew imparted to it by its own gravitation—a motion in a vertically descending direction.

This admission of his is followed by the other that "Pelton stopped half-way with reversion of stream." This was not so stated in my history of the evolution of the American Hurdy-Gurdy, it being there stated that "Pelton stopped half-way with his improvements." (Compare p. 9 second column of pamphlet of American Impulse Wheel Co.)

The impact between jet-water and vanes takes place in the Cazin wheel near its lowest extremity. (Compare Fig. 1.)

The course of the jet through the vanes terminates on the laterally outer half of each of the two vane-cavities, and these outer halves project on each side of the wheel-crown and disk, leaving the road clear for the water, after losing all of its force, when moving exclusively by its own gravity, to fall away from the wheel, which in its lower part is not, as for good cause it is in its upper part, hugged in by its housing. (Compare Fig. 2.)

This is the actual state of affairs, which by each actual

test of the Cazin wheel is demonstrated anew, notwithstanding all that Mr. L., Jr., has read from the cuts, amongst other things that "the water after completing its work, does not clear the wheel," that "Mr. Cazin puts on the wheel a friction brake of dead water," that "it is hardly possible to calculate the loss due to backwater, even when the discharge (?) but partially interferes," or "when the interference is complete." Mr. L. Jr., leaves his individual understanding of cuts absolutely without all or any other support than that he so read them "from the cuts."

It would be like carrying into the Pacific tears that were shed at the wrongs suffered by the Pelton Water Wheel Co. to further discuss with him the percentage of a loss that does not exist in fact, or of an effect without cause, or the—by him—understated percentage of a loss which he admits the existence of in the Pelton wheel.

But Mr. L., Jr., is not contented with claiming without any proof whatever that Mr. C. put a friction brake to his power wheel by keeping the water from obeying the law of gravitation; but, after first admitting complete inversion by admitting the loss of all velocity, he denies in second thought constant inversion, declaring it a practical impossibility, which by his assertion can only be removed "when the radius of the wheel approaches infinity."

Evidently Mr. L., Jr., has overlooked the fact that inversion must take place between the instant when the jet makes its contact with the vane and the other instant when it has lost such contact, the inversion relating to the direction in primary contact and to no other.

Mr. L., Jr., has also a word to say about the Cazin wheel having "twice as many buckets as necessary." Can

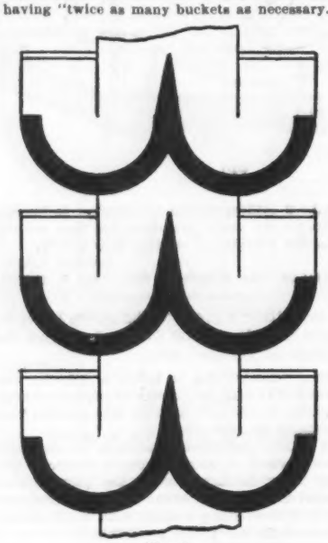


Fig. 2.

Mr. L. Jr., quote any authority besides his own for curtailing, except for want of space, the number of buckets on the crown of impulse water wheels, the selection of proportional dimensions of vane and wheel depending on conditions of which Mr. L., Jr., has evidently no suspicion.

He has quoted two causes for curtailing the number of vanes:

(1) Friction; (2) Entrance-disturbance.

If the number of vanes does not modify the quantity of ejected water or its velocity, then there is no more friction when three equal fractions separately come into contact with three separate vanes, or when all three fractions come in contact with the same vane. When the entrance of the vanes into the jets causes disturbance, as in fact it does in all water-wheels except the Cazin wheel, then greater plurality of vanes increases such disturbance. But, when the conditions of entrance of vanes into the jets are, as they are in the Cazin wheel, in which the outer vane-face stands parallel to the jet, just before the vane enters the same (compare patents of March 16, 1897) and in which the vane's advance lips enter the jet as a chisel would enter metal, viz.: with an intial line and not with a blunt face, and with a sharp angle—in that case there remains no entrance disturbance.

The representation of the Pelton wheel borrowed from the Pelton catalogue, with only the wheel turned for a few degrees, shows that in the Pelton wheel there must be some entrance disturbance, as in fact there is, because the jet hit the vanes in some of their positions in the back. And under this condition there exists in the Pelton a cause for curtailing the number of vanes which in the Cazin does not exist. (Comp. Fig. B.)

Once more it is claimed by an agent of the Pelton Water Wheel Co. that their wheels give "commercial efficiency of from 85 to 93 per cent.," and this is done in the face of an unchallenged proof that some of the certificates on which these claims are based have in fact, but inadvertently, certified to 102.5 per cent. of efficiency, viz.: to an impossibility (compare illustrative calculation in the pamphlet of the Am. Imp. Wheel Co. and Elec. Age, vol. xvi., 3 and 4), and in face of the other unchallenged fact that the authority quoted for another one of these efficiency claims denies having ever made a test of the Pelton wheel, and in the face of an unaccepted public challenge for a comparative test. (Compare the pamphlet of the Am. Imp. Wheel Co., p. 42, last paragraph.)

A hydraulician of well-established authority, Philip R. Bjorling, the author of "Water or Hydraulic Motors," (London, 1894), has not hesitated to declare the Cazin wheel as the "best hurdy-gurdy or impulse water-wheel." (Compare the "Colliery Guardian" of June 4, 1897). To what then does such criticism amount as advanced by an unknown writer who shows the earmarks of his motives?

I nevertheless thank Mr. L., Jr., for his sympathetic expression in relation to the use of my time and to the use of their money by the American Impulse Wheel Co. I sincerely hope that when Mr. L., Jr., will have reached the age of 70, as I have, he will be able to look back to the use he made of his time with the same contentment that I do, and that those who invest by his advice will be as contented as the American Impulse Wheel Co. is of their enterprise.

F. M. F. Cazin.

1108 Bloomfield street, Hoboken, N. J., June 18, 1897.

POT-HOLES AND THE MT. LOOKOUT CAVE.*

By Wm. Griffith.

During what is sometimes called the "Ice" or "Cold" Age, Canada and the northern part of the United States, as far south as central Pennsylvania, was covered with a solid blanket of ice. In the vicinity of the Wyoming coal basin this icy sheet is supposed to have been about 2,000 ft. in thickness. As is usual with glaciers, the whole mass slowly moved southward, gouging and plowing the surface of the earth, scratching and breaking the rock and transporting stones and bowlders of all sizes long distances, finally depositing them far from the place of their original occurrence. In this glacial area the rock is usually covered by a variable thickness of "drift" or "glacial till," consisting of various layers of sand and rounded gravel, with bowlders large and small, all more or less worn by the action of the water and moving debris. In some places where large streams were probably flowing under the ice, deep channels were worn in the rock and subsequently filled with glacial drift deposit, and, of course, where these channels were deeper than their outlets lakes of still water were formed, and these oftentimes were filled to considerable depth with fine silt or quicksand, clay, gravel, etc.

One of these submerged channels extends through the length of the Wyoming Valley, and is often referred to as the "Buried Valley" of Wyoming. The rock has been worn away to a depth of from one to two hundred feet, eroding some of the upper coal seams in places and leaving an uncertain thickness of rock roof over the underlying coal.

Another phenomena or freak resulting from glaciers is the formation of pot-holes. A glacial pot-hole is a deep shaft, well or hole, worn in the solid rock by action of water falling from a height (probably through a crevice in the ice) on to the solid bed rock, thus, by the aid of fragments of stone and bowlders which are kept in continual motion in the bottom of the hole, wearing the well deeper and larger with time; the size and depth of the pot-hole depending on the volume of water and the height of fall. Pot-holes are in process of formation at the present in Alpine glaciers and elsewhere, and in Switzerland some of these are preserved for public inspection and instruction. Minute pot-holes varying in size from a pint measure to a hogshead are often found worn in the bed rock of our mountain streams—formed in the same way, by the water falling from a ledge and keeping the small pebbles in motion in the bottom of the hole. A good idea of this action can be obtained by placing some pebbles in a tumbler and putting it under the water flowing from a faucet.

The existence of pot-holes in the anthracite coal region was first discovered about the 1st of February, 1884, when one of the chambers of the Eton Colliery at Archbald, owned by Jones, Simpson & Co., and located on the mountain side high above water level, was driven against a mass of round stones of all sizes from pebbles to bowlders a foot in diameter. Subsequent investigation revealed the existence of an oval-shaped shaft from 20 to 40 ft. in diameter worn through the rock from the surface. The walls of the pot-hole were smoothly worn, and fluted and corrugated spiral grooves showed the unmistakable action of water and stones. This pot-hole had cut completely through the coal bed, and among the bowlders in the bottom of the hole were quantities of round lumps of coal which had evidently been cut from the vein. This pot-hole is now used as an air shaft for the mine. A wall has been built around the top, and it may be inspected at any time.

A second pot-hole was found later at the same mine, about 1,000 ft. northward of the first. It has, however, never been cleared of its contents of glacial drift. About twenty years ago, previous to this discovery, an accident occurred which is now thought to be due to a pot-hole. The case referred to was at the Wyoming Colliery, operated by Swoyer & Co., now the Lehigh Valley Coal Co., at Port Bowkly Station, on the Lehigh Valley R. R. The mines were under the buried valley, and were filled with debris from the supposed pot-hole, the cave occurring near the solid coal and extending to the surface. Some coal cars (jimmies) which were standing on the siding of the Lehigh Valley R. R. were swallowed up in the cave. This debris, sand, water, stones, etc., has since been cleaned away from the gangways and the mine completely recovered. Dams have been built around the base of the pot-hole so as to protect the mine from a recurrence of the trouble. During the progress of this work some of the coal cars, broken to fragments, were found distributed along the gangways of the mine some distance from the base of the pot-hole.

Since the discovery of the Archbald pot-holes two serious mine accidents have occurred in the mines under the "Buried Valley" of Wyoming, which are unquestionably caused by the existence of some form of glacial pot-hole in the strata overlying the beds. The first of these—which was one of the most disastrous mine accidents of the region—occurred Dec. 18, 1885, at the Susquehanna Coal Co.'s mine, Nanticoke, Pa. At the edge of the solid coal near the face of a chamber, a flood of water, sand, rounded stones, etc., suddenly and without warning of any kind broke into the mine, filling up 100,000 cu. yds. of workings. The lives of 26 men were lost in this accident, and it was found impossible to recover their bodies.

The last accident of this nature has but just occurred

*A paper read at the annual meeting of the Anthracite Coal Operators' Association, 1897.

WEATHER TABLE FOR MAY, 1897. (Furnished to Engineering News by the Department of Agriculture.)

	Stations.	Temperature. (Degrees Fahrenheit.)				Wind.			Precipitation—rain or melted snow—inches.		
		Average.	Max.	Min.	Range.	Velocity in miles per hour. Average.	Velocity in miles per hour. Max.	Direction at time of max. velocity.	Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities.	Northfield, Vt.	51.9	77	24	53	9.0	36	S	3.46	.88	13
	Portland, Me.	52.2	74	36	38	7.2	38	S	5.87	1.69	19
	New York City	59.3	79	44	35	13.7	48	E	5.30	1.87	11
	Pittsburg, Pa.	58.0	81	37	44	6.0	28	S	2.70	1.22	15
	Chicago, Ill.	55.0	81	33	48	16.3	49	N	.84	.45	10
	Omaha, Neb.	61.8	87	38	49	7.7	26	NW	2.16	.98	11
	St. Paul, Minn.	56.8	86	34	52	7.8	31	S	1.81	1.11	10
	Duluth, Minn.	48.4	87	32	55	9.1	36	NE	1.63	.54	13
	Bismarck, N. Dak.	57.2	90	28	62	11.2	36	NW	1.10	.88	6
	Average.	55.6	82	34	48	9.8	36		2.76	1.07	12
Southern Cities.	Washington, D. C.	62.4	83	43	40	7.6	32	N	6.97	2.81	12
	Louisville, Ky.	61.6	90	37	53	7.4	31	W	3.30	.92	12
	St. Louis, Mo.	63.5	84	43	41	8.7	29	SW	1.59	.78	9
	Savannah, Ga.	72.8	94	51	43	8.6	25	W	1.10	.53	5
	Kansas City, Mo.	64.5	87	41	46	7.3	29	NW	1.24	.56	10
	Jacksonville, Fla.	73.2	93	53	40	8.3	28	SE	1.35	.82	6
	Chattanooga, Tenn.	66.0	87	42	45	7.0	32	SW	3.26	1.18	7
	New Orleans, La.	74 3	88	58	30	7.9	32	N	.25	.16	4
	Memphis, Tenn.	68 2	90	48	42	8.3	26	W	1.37	.70	8
	Palestine, Tex.	71.8	89	48	41	5.0	20	SE	4.27	2.18	11
	Average.	67.8	88	46	42	7.6	28		2.47	1.06	8
Western Cities.	Helena, Mont.	60.0	83	35	48	8.6	48	SW	1.14	.46	7
	Port Angeles, Wash.	51.8	78	38	40	7.4	30	W	.63	.30	6
	San Francisco, Cal.	57.4	88	47	41	13.5	45	W	.61	.61	2
	Salt Lake City, Utah.	63.7	88	35	53	6.7	40	S	.98	.48	6
	Santa Fe, N. Mex.	56.9	74	36	38	6.7	36	SW	4.35	2.12	15
	Denver, Colo.	60.6	84	40	44	7.4	42	N	3.15	1.41	9
	Yuma, Ariz	Discontinued									
	Average.	58.4	82	38	44	8.4	40		1.81	.90	8

at the Mt. Lookout Colliery at Wyoming, Pa., operated by Simpson & Watkins. The workings of this mine are located under the center of the buried valley. The shaft was sunk by pneumatic process through the quicksand, clay, gravel and water to a depth of 100 ft. or more, and through the rock by the ordinary process to the vein below. The management was thoroughly posted as to the conditions, and have from the first used every precaution for the protection and safety of their workmen and mine. To this end a pumping capacity of upwards of 4,000 gallons per minute had been provided inside the mines to handle any sudden increase or flood of water, and 60 or 70 diamond drill holes had been bored on the property to test the thickness of the drift and rock overlying the veins in advance of the workings. One of the gangways had extended westward about 3,000 ft. from the shaft, and nearly under the center of the village of Wyoming. The rock roof for several hundred feet in advance had been tested by bore holes and five of them sounding the locality in advance of the workings, at the point where the accident occurred, had proved the drift to average about 100 ft. in depth, and the rock roof overlying the coal was found to be from 50 to 80 ft. in thickness. Hence, no trouble was expected at this point.

During the afternoon of March 1, 1897, the surface under the Wyoming postoffice began to settle. The mines were idle and no one working at this point. Inspection by the mine officers revealed the fact that a break had occurred near the face of the most advanced workings at the edge of the solid coal, resulting in a flood of water and quicksand, filling a large area of the workings and carrying the debris to the foot of the shaft, 3,000 ft. away. The volume of the flood, however, gradually diminished, and the pumps being adequate for the emergency, the water in a short time began to subside, the flood of sand stopped and the break checked and filled. Not, however, until about 70,000 cu. yds. of quicksand had been washed into the mine, causing a surface depression, or cave, about 300 ft. in diameter and 25 ft. deep, which engulfed the postoffice completely and did some damage to three other dwellings.

The cirmumstances of this accident and the evidences accompanying it show unquestionably the presence at this point of a glacial pot-hole, which was of sufficient depth —50 to 75 ft. at least—to cut the vein of coal in which the mines were operated. The first rush of sand and water carried with it a quantity of rounded water-worn lumps of coal, which were deposited near the shaft and in the gangway leading therefrom. Quantities of sandstone and bowlders, all worn round and smooth, were found deposited with the quicksand at points close to the break, showing that the bottom of the hole probably cut through the coal vein, and from it the bowlders of coal were made and carried into the mine. The sandstone bowlders which were either mixed with the coal or overlying it, were carried in by the sand which followed the first rush, but, owing to their greater weight, were not transported far.

Since the occurrence the mine officials have been able by a circuitous route to approach within about 120 ft. of the break, and have discovered no indications whatever of a cave of the roof or squeeze of the pillars. A miner was at work in the chamber in which the accident happened, and one also in the adjoining chamber, during the afternoon of the accident, but left their work a few hours before the break occurred. Neither of these men noticed any warning of trouble such as usually precedes a squeeze, nor any other unusual or suspicious thing in their working places. The management will take precautions against a possible future recurrence of the trouble by placing strong dams at several points, closing off an area of several acres of old workings, which will be abandoned, and, if thought necessary, probably washed full of culm. The mine was idle about six days on account of the accident, but it is now in operation, producing its usual quota of coal.

BENDING MOMENT DUE TO CONCENTRATED LOADS.

By H. Szlapka.

Let A B represent a girder of the length l, loaded by any number of concentrated wheel-loads. In order to make the demonstration perfectly general and to simplify the work, let P_3 represent the load standing on the point at which we wish to obtain the bending moment, and let us call P_2 the critical load. Let P_1 and P_2 stand for the resultant of any number of wheels to the right and left of the critical load respectively, and let a and b be the distances of the centers of gravity of the systems of wheels represented by P_1 and P_2 from P_2.

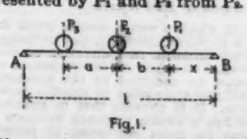


Fig. 1.

The reaction at left support will be for any position of the loads, x being the distance of P_3 from the right support,

$$R = \frac{P_3 a}{l} + \frac{(P_2 + P_1)b}{l} + \frac{\Sigma Px}{l}$$

$$= \frac{\Sigma Px}{l} + \frac{P_2 a}{l} + \frac{P_1 b}{l} + \frac{P_2 b}{l} + \frac{P_1 b}{l} - \frac{P_1 b}{l},$$

$$= \frac{\Sigma Px}{l} + \frac{P_3 a}{l} + \frac{\Sigma Pb}{l} - \frac{P_1 b}{l}.$$

Now, let us represent the expression $P_3 a - P_1 b$ by ΣPd^1, which symbol will therefore stand for the "algebraic sum" of the moments of all the loads taken around the critical load as origin, regard being had to the sign of the moments.

Then we will have

$$R = \frac{\Sigma Px}{l} + \frac{\Sigma Pb}{l} + \frac{\Sigma Pd^1}{l} \qquad (1)$$

The bending moment at P_3 will be

$$M = R(l - x - b) - P_3 a \qquad (2)$$

Substituting the value of R from eq. (1) and differentiating with respect to x we get

$$\frac{dM}{dx} = 0 = \frac{\Sigma P(l-x-b)}{l} - \frac{\Sigma Px}{l} - \frac{\Sigma Pb}{l} - \frac{\Sigma Pd^1}{l}$$

whence we derive

$$x = \frac{l}{2} - b - \frac{\Sigma Pd^1}{2\Sigma P} \qquad (3)$$

This value of x makes the value of the bending moments produced by all the loads on the span a maximum and proves the well-known rule first given for maximum moment by Prof. Culman in his work on Graphical Statics: The loads on the span must be so placed that the center of gravity of the load system and the critical load are at equal distances from the center of the span. Substituting this value of x in equation (1) we derive

$$R = \frac{\Sigma P}{2} + \frac{\Sigma Pd^1}{2l}$$

and then putting the values for R and x in equation (2) we get

$$M = R\left(\frac{l}{2} + b + \frac{\Sigma Pd^1}{2\Sigma P} - b\right) - P_3 a$$

$$= \frac{\Sigma Pl}{4} + \frac{\Sigma Pd^1}{2} + \frac{(\Sigma Pd^1)^2}{4\Sigma Pl} - P_3 a$$

Now

$$\frac{\Sigma Pd_1}{2} - P_3 a = \frac{P_3 a - P_1 b - 2P_3 a}{2} = -\frac{\Sigma Pd}{2}$$

The symbol ΣPd stands for the arithmetical sum of the moments of all the loads around the critical load as origin, no regard being had to sign.

The final expression for the maximum bending moment becomes

$$M = \frac{\Sigma P}{4}\left\{l + \left(\frac{\Sigma Pd^1}{\Sigma P}\right)^2 \times \frac{1}{l} - \frac{2\Sigma Pd}{\Sigma P}\right\} \qquad (4)$$

This formula is perfectly general and requires for its application to any given case the knowledge of the critical load only. This load can usually be fixed by inspection, but in a doubtful case substitutions in the formula are quickly made and will determine the matter without much trouble. In ordinary practice with engine diagrams as used by the different railroad companies the value of the term

$$\left(\frac{\Sigma Pd^1}{\Sigma P}\right)^2 \times \frac{1}{l}$$

becomes very small and can be entirely neglected for spans of over, say, 30 ft. The error in neglecting this term for a 30-ft. span would be some-

Fig. 2.

what less than 1%, while it rapidly becomes smaller as the span increases. Omitting, then, this term, equation (4) will take the form

$$M = \frac{\Sigma Pl - 2\Sigma pd}{4} \qquad (5)$$

The significance of this formula will be shown as follows:

In Fig. 2 let us suppose a support C, inserted in the center of the span A B and let the load P_3 be placed on C. The concentration at C will then be

$$C = \frac{P_1\left(\frac{l}{2} - b\right) + P_2\left(\frac{l}{2} - a\right)}{\frac{l}{2}} + P$$

$$= \frac{P_1 l - 2P_1 b + P_2 l - 2P_2 a + P_3 l}{l}$$

$$= \frac{\Sigma Pl - 2\Sigma Pd}{l} \qquad (6)$$

Dividing equation (5) by eq. (6) we get

$$\frac{M}{C} = \frac{l}{4} \qquad \text{or } M = \frac{Cl}{4}$$

If we call $\frac{1}{2} = 1^1$ we have $M = \frac{Cl_1}{2}$ (7)

This equation shows that the maximum bending moment is directly proportional to the floorbeam concentration at the center of the span, considered as being divided into 2 equal spans. Calling M, the sum of the moments of all the wheels in reference to P_1 and M_1 the sum of the moments of all wheels up to P_2 in reference to P_2, it can easily be shown that

$$C = \frac{M_1 + \Sigma Px - 2M_1}{l_1}$$

which gives by inspection of eq. (7)

$$M = \frac{M_1 + \Sigma Px - 2M_1}{2}$$

This method gives a correct result for any length of span above, say, 30 ft. very rapidly, and has been used by the author for a number of years with a great saving of time and labor. For shorter spans formula (4) has been found to be very simple and direct in application. For the special case of two equal loads P, with a wheel base a eq. (4) takes the form

$$M = \frac{P}{2l}\left\{l - \frac{a}{2}\right\}^2$$

For 3 loads equally spaced

$$M = P\left\{\frac{3}{4}l - a\right\}$$

For 4 loads equally spaced

$$M = P\left\{l + \frac{a^2}{4l} - 2a\right\}$$

SIGNAL LIGHTS AND DERAILS.

At the March meeting of the Railway Signaling Club, of Chicago, Mr. H. M. Sperry read a paper on "Some Signal Problems." We abstract it as follows:

In the combination distant signal lamp used on the Chicago & Northwestern Ry. since 1890, and which costs but little more than an ordinary semaphore lamp, two colored lights, red and green, are shown by means of one flame. A 5⅜-in. red lens is in front of the flame, while a ray of light is reflected through a 7-in. opening covered with green glass, the two lights being 9½ ins. c. to c. When the signal arm is horizontal the two lights are displayed, and can be distinguished at a distance of half a mile in ordinary weather, while at a greater distance the red is first seen. When the arm is lowered only the reflected green light is shown. The Chicago, St. Paul, Minneapolis & Omaha R. R. has decided to adopt this system. A few roads are using more than one lamp to each signal, but they are exceptions to the rule. On English railways red is used for "stop," and green for "clear," both on home and distant signals, though formerly green was used for "caution" and white for "clear." In this country the colored glasses are practically the same size as the lamp lenses, so that any slight dropping of the blade will tend to show a portion of the white light. This can be avoided by using oblong glasses, as in English practice, thus providing for a certain amount of lost motion.

The semaphore is our standard block signal and is rapidly replacing all other forms. There are three different methods of giving block signal indications, the almost

universal practice being horizontal for "stop," inclined at an angle of 45° below the horizontal for "caution," and almost vertical for "clear." A feeling that the difference between the "caution" and "clear" indications was not enough led to a design in which the "clear" indication is given by the absolutely vertical position, the arm being so centered as to stand clear of the post; another gives the "caution" indication by raising the arm to an angle of 45° above the horizontal. To operate the signal for these three positions, the lever stands normally at the middle of its full stroke and is moved from its middle position in one direction for "caution" and in the opposite for "clear." This feature makes an unsatisfactory arrangement for use in an interlocking machine, and some one has suggested 45° above the horizontal for "stop," horizontal for "caution" and 45° below for "clear." This would be a radical change, with the only advantage that the three positions could be operated by an interlocking machine. It would be just the reverse of the German practice, which is horizontal for "stop," and above the horizontal for "clear," and the Germans undoubtedly displayed very good judgment, as an accumulation of snow and ice on the arm in the "clear" position would only tend to force it to the "stop" position. The best permissive signal is to use a second arm, with both arms horizontal for "stop," one arm dropped for "caution" and both arms dropped for "clear." (Eng. News, Oct. 22, 1896.)

A distant signal must be located at such a distance from the home as will enable a train to stop at the home signal, if when passing the distant signal it is found to be in the "caution" position. For this 1,200 ft. is not enough; 1,500 ft., as used on some lines, is better, and if trains are to be run at high rates of speed, 2,000 ft., a distance used on many lines in the east, would be better yet. The distance, however, should be determined by the local conditions, and, in fact, in some cases, no distant signals whatever are necessary, as it is certainly bad practice to erect distant signals that are never used. Distant signals not in sight from the tower should be provided with electric repeaters, and some method of checking the operation of distant signals is desirable, so that carelessness in their operation by allowing them to stand constantly at danger can be guarded against.

A question of importance is the use of derails and the distance that they should be located from their danger points. They are more extensively used in the west than in the east, although in the east trains are more frequent and run at a higher rate of speed. Have we overdone the matter in the west or do they need more derails in the east? Derails suggest the question of electric locking, and great credit should be given to some of our western lines that have pushed this matter to the front. There are numerous successful applications of electric locking, entirely removing the danger of changing a signal and derailing the train after a train has once accepted it. The number of mistakes that have been made through an improper changing of signals clearly shows the necessity of electric locking.

Selectors are not now being used to such an extent as formerly, and in fact they were only brought forward as an economical device. They should never be used for converging routes, as conflicting signals are then operated by the same lever, and a failure of the selector or its connections might lead to a wrong signal being given.

The signal adopted by Mr. Webb, of the London & Northwestern Ry., is of the ordinary semaphore type, the poles being of pitch pine varying in size from 9 × 9 ins. to 15 × 15 ins. at the bottom (according to the height of the post) to 6 × 6 ins. at the top, upon which is placed a galvanized iron cap. The bottom part of the post, for about 7 ft., is left the full size of the timber from which it is cut, and thus, at the ground level, where the process of decay is most rapid, 10 ins. or more timber is left, which, after being charred, is well coated with gas tar. The signal arm is formed of a thin steel plate, stiffened by two corrugations running lengthways of the arm; this is riveted to a galvanized cast-iron center upon which is fixed an adjustable frame for the spectacle glasses, made sufficiently heavy to counterbalance any accumulation of snow on the arm and to keep it in its danger position should any of the fittings fail. The arm works on a spindle squared to receive it at one end, and the back light lever at the other, and the spindle turns in a casting fastened to the post by four ⅝-in. bolts, which also serve to secure the lamp bracket placed at the back of the arm. This is of sufficient width to form a stop for the arm when at "stop" position.

In the discussion of this paper, which took place at the May meeting, Mr. Macdonough (Chicago & Erie Ry.) thought that the practice of using a white light for "track clear" should be changed, and he approved of red for "stop," green for "track clear," and the combination of red and green for distant signals.

Mr. Gillingham (Illinois Central R. R.) said that the use of the white light for "stop" would solve the question with very little complication as far as signaling is concerned. The idea of adopting green for "clear" is to eliminate white entirely as a signal, but if a spectacle or a green lens were broken the white light so displayed would become a stop or danger signal, and, therefore, why should not white be adopted as a "stop" signal under all circumstances. He considered, however, that this change would be so radical that the proposition would never be considered by railway companies. If red is adopted for "stop" and green for "clear," then the combination of red and green would be the most consistent for "caution."

Mr. Macdonough thought that the use of white for "stop" would introduce many complications. The hand lamp signals would have to be changed, colored lamps being substituted, but these colored lamps would be of no use to a conductor in walking along his train to check the numbers of his cars.

Mr. Gillingham thought the point was well taken as to the application of derails. He considered that in the west the restrictions are entirely too severe, and compel railway companies to put in derails where they are really useless and simply add to the element of danger rather than prevent it. There are many cases where reverse movements are not made, but nevertheless the rules of the several railway commissions require that derails must be put in.

Mr. Miles thought that the distance of the derail from the danger point should be carefully considered. The derail for an interlocked crossing or a drawbridge should be 500 ft. distant, and means should be taken to prevent a train reaching the crossing, as in winter a derailed train might run over the frozen ground as far as the crossing. The guard rail should be extended 300 ft. beyond the derail towards the crossing, and have turnout points put in to divert the train into the ditch; this distance would materially check the speed, and there would ordinarily be no serious danger of loss of life. In some cases, however, something would have to be done to prevent a derailed train from going over a high bank. He considered it advisable to carry the train on the ties for some distance before diverting it from the track, as the ditching of a train at high speed would be very likely to cause loss of life.

Mr. Macdonough suggested the use of a sand track beyond the derail. He did not approve of a simple derail, but considered that it would be better to put in a diverting track. There are a great many accidents in which a train goes off the derail when there is no train on the opposing track, which would seem to indicate that trains are being derailed simply to discipline the men and teach them the use of the derail.

Mr. Seitz (Chicago & Northwestern Ry.) thought a derail would have prevented the serious grade crossing collision near Atlantic City, N. J., last year.

Mr. Gillingham, however, disputed this, on the ground that on the long level stretch of line both trains were racing for the crossing. He stated that Eastern roads use very few derails and that their percentage of accidents is very much less than on the Western roads, so that the question resolves itself into one of discipline and the employment of a higher grade of men. He questioned the value of derails on easy grades and level country, and instanced a case where a derailed train ran 400 ft.

Mr. Sperry said that he thought a careful investigation of the Atlantic City accident had shown that the signal engineer did not have control of the arrangement of the signals, but was ignored when new tracks were built, the signals not being then placed so as to prevent any kind of an accident.

ANNUAL CONVENTION OF THE MASTER MECHANICS' ASSOCIATION, OLD POINT COMFORT, VA.

(Concluded from p. 381.)

Second Session.

The discussion of the 1896 report on exhaust nozzles, which had been continued from the first session, was of considerable length and quite active, and only the more important features can be given in the space available here. Mr. E. M. Herr (Nor. Pac.) stated that to determine the general application of the recommendations of the report he had applied them to the designing of the front end of a locomotive having a boiler of some 14 inches greater diameter than that on which the committee's experiments had been made, and the result had been satisfactory. Mr. R. Atkinson (Can. Pac.) stated that he had tried the design recommended by the report shortly after its presentation in 1896 and found that a decided improvement resulted. Mr. Atkinson's remarks were practically duplicated by Mr. Cockfeld, Mr. P. H. Peck (C. & W. I.), Mr. A. L. Humphrey (Colo. Mid.), Mr. Robert Quayle (C. & N. W.) and several others. Mr. William Forsyth (C., B. & Q.), a member of the committee which made the report, called attention to some precautions necessary in applying its recommendations, as follows:

We applied this pipe to quite a large number of engines of different classes, and the first thing we found in doing so was that if we made the size of the choke the normal size of the nozzle and then continued to enlarge the nozzle it made little difference in the effect on the fire; in other words, the area of the choke is the virtual area of the nozzle. I think a great many have been deceived into thinking that they are running with a large nozzle when they are running with a small choke, and the effect on the fire is perhaps wasteful, when they imagine they are doing a good thing because they have a large exhaust exit and really have a small exhaust blast area. The practical application of this is, in making the patterns for exhaust nozzles, that the area of the choke should not be made exactly as the committee recommended, namely, equal to the diameter of the exhaust tip in area, but it should be made of an area equal to the largest exhaust tip you expect to use, or larger. If this choke is made equal to the normal size of the nozzle it is liable to become gummed up gradually by the lubricants and grease which come through the nozzle, and it will become smaller; so that while we may think we are running with five-inch nozzle we may have the exaust area down in the choke reduced to a smaller area, and that is the reason for make the choke larger than 100% of the nozzle. This relation of the choke to the final exit is the most important part of the proportions which the committee have recommended.

Counterbalancing Locomotives.

This committee, which reported a system for counterbalancing locomotives at the convention of 1896 (Eng. News, July 2, 1896), was at that time ordered to be continued with instructions to designate a number of railways to confirm or disapprove the efficiency of the system by actual trial. The committee designated eleven railways, of which number only four reported results. These four reported favorably regarding the system, and in a number of other cases where the committee took pains to make special inquiry, favorable reports were also received. It therefore repeated the former recommendations, which were as follows:

(1) Divide the total weight of the engine by 400; subtract the quotient from the weight of the reciprocating parts on one side, including the front end of the main rod.

(2) Distribute the remainder equally among all driving wheels on one side, adding to it the weight of the revolving parts for each wheel on that side. The sum for each wheel, if placed at a distance from the driving-wheel center equal to the length of the crank, or a proportionately less weight if at a greater distance, will be the counterbalance required.

The discussion on this report was opened by Mr. G. R. Henderson (Norf. & Wn.), who stated that in the second clause of the committee's recommendation it was stated: "distribute the remainder equally among all driving wheels on that side." He thought as long as you got the reciprocating weights balanced among the wheels on that side that it did not make any difference whether they were divided equally among all the wheels or not. He, of course, did not mean by this that a safe weight on the rail should ever be exceeded. Mr. Puluski Leeds (L. & N.) took exception to Mr. Henderson's practice as involving a danger to the rails. Mr. William Swanston (C., St. L. & P.) stated that he had employed both the practice recommended by the report and by Mr. Henderson and that both had worked satisfactorily. Mr. William Forsyth (C., B. & Q.) stated that the question of counterbalancing, so far as it related to the riding of the locomotive, was one of the maximum allowable weight on the rail and of the maximum stress on the rail. He had a series of curves for all of his locomotives, which showed the maximum allowable speed for any assumed tonnage stress on the rail. The total pressure was the static weight on the driver plus the centrifugal force. These curves showed that at even as low a speed as fifty miles per hour with some of his engines he had a total load of 20,000 pounds per wheel, and at sixty miles per hour the total was 22,000 pounds per wheel. In designing new engines he was continually met with warnings from the roadmasters that he must not exceed a certain limit of weight, and it was remarkable how different were the opinions as to what that weight should be. It was often regardless of the weight of the rail section. He thought the point had been reached where the association ought to have the assistance of the American Society of Civil Engineers and rail manufacturers in giving it some information as to what maximum stress can be allowed on different sections of rails.

Truck Swing Hangers.

In a preliminary report which this committee submitted at the convention of 1896 it said:

The function which a swing-motion truck should perform is to be able to move sideways, but in doing so it should exert a pulling action in that direction on the front of the engine somewhat in excess of the resistance of such movement. It must be admitted by the committee that they have little definite knowledge in relation to the amount of this resistance. It is obvious that in running in a curve a locomotive has a strong tendency to move in a straight line, and that its front end must be pulled toward the centre of the curve, but the amount of the lateral motion resistance which must be overcome on curves is unknown. Obviously it consists of two components, the friction of

the wheels on the rails and the centrifugal force of the engine. What these actually are for different curves, speeds and engines, so far as the committee is aware, is not known, and they suggest that the determination of the lateral force which must be exerted to guide the front end of a locomotive on curves offers an inviting and probably a profitable field for experimental investigation.

To solve, if possible, some of the problems suggested in this preliminary presentation of the subject Mr. William Garstang (C., C., C. & St. L.) constructed and applied to a locomotive a special dynamometer recording device which would show the swing of its boiler and the truck flange stress in running at various speeds around a 3° curve. The results of the tests made are shown in the accompanying table:

	With 8-in. hanger—			With 6½-in. hanger—		
Angle of hanger, inside angles.	Ave. speed, miles per hr.	Total boiler swing, ins.	Truck flange stress, lbs.	Ave. speed, miles per hr.	Total boiler swing, ins.	Truck flange stress, lbs.
45°	32.86	0.706	3,562	33.33	0.575	2,648
39°	32.19	0.796	3,022	33.33	0.393	1,869
33°	33.15	0.934	2,926	33.33	0.450	1,753
28°	32.50	0.946	2,849	32.17	0.606	1,706
23°	32.33	1.039	3,289	31.25	0.604	1,592
18°	32.99	1.103	3,171	31.75	0.607	1,560
12°	31.36	1.673	3,081	33.11	0.676	1,753
10°	32.25	1.951	3,440	34.13	0.706	1,779
8°	33.37	1.720	3,163	34.08	0.795	1,902
6°	32.77	2.002	3,726	32.96	1.008	1,969
4°	33.41	2.190	3,239	33.19	1.156	2,236
2°	32.33	2.080	3,612	32.33	1.369	2,637
Vertical	32.58	1.971	3,640	35.50	1.609	2,522
Outside angles.						
2°	33.11	1.897	3,220	33.25	1.442	2,203
4°	32.83	1.821	3,249	33.00	1.603	2236
6°	33.00	1.801	3,092	32.16	1.520	2,464
8°	33.41	1.721	3,038	33.16	1.544	2,264
10°	32.83	1.826	3,239	34.75	1.695	2,551
12°	33.58	1.814	3,150	33.58	1.518	2,322
Rigid truck	32.30	0.506	3,229	.....	.....	.....

In commenting upon these figures the committtee says:

It will be noticed by the tabulated statement that the angles giving the best results for the two hangers in this test were 18° for the 6½-in. hanger and 28° for the 8-in. hanger, which leads the committee to believe that the angle of the hanger should be changed for each length of hanger used.

While the results obtained from these tests are very interesting, and may be said to be conclusive for a locomotive of the type used and under the conditions under which the tests were made, your committee feels that sufficient information has not been secured to enable them to answer conclusively the question propounded, and believes that to do so will necessitate making a series of tests with the different types of engines for which the information is desired under different conditions as to gage of track, degrees of curvature, etc., and if the association feels that it is desirable to pursue this investigation further that it would be advisable to set aside a sufficient amount of money to defray the expenses of making such tests, as the expense incident to making such elaborate tests will be considerable, and it would not be right to expect any railroad company to make them at its own expense.

No discussion followed this report, and the convention took no action regarding continuing the tests or any further study of the question.

Locomotive Grates for Anthracite Coal.

The subject upon which this committee was directed to report was what kind of grate is the most suitable for burning anthracite coal, the cast-iron shaking grate or the water-bar grate? The report was quite long and described and illustrated in considerable detail the practice of a number of railways using anthracite coal in their locomotives. Summarized briefly, the committee recommended: (1) For fire boxes over the drivers, transverse shaking grates alone or longitudinal shaking grates lightened with water tubes between; (2) For fire boxes not extending over the drivers, shaking grates alone.

This report was briefly discussed by Mr. F. F. Gaines (Lehigh Valley), who stated that he preferred the longitudinal shaking grate, as it seldom broke and was easily removed. He used no water bars at all.

The Apprentice Boy.

At the convention of 1896 this committee submitted a report treating particularly of the necessity of educating the apprentice boy outside of the shop. The present report referred more particularly to the shop training. Based upon a four years' term, schedules of work were presented for machinists' apprentices, blacksmiths' apprentices and boiler makers' apprentices, and a course of study for night schools was submitted, with forms of indenture and release. In each of the schedules the exact time to be spent on each class of work was given in detail, and of course the arrangement of each schedule differed. The following general rules, however, applied to all classes of apprentices:

(1) For machinist apprentices, only those who are over 16 years of age or less than 20 years of age.

(2) For blacksmith apprentices, those who are over 16 years of age and under 24.

(3) For boilermaker apprentices, those who are over 16 years of age and under 24.

(4) All applicants for positions as apprentices must pass a creditable examination in all the studies taught in the public schools up to and including the eighth or grammar grade.

(5) Each person so employed under the age of 21 years will be obliged to furnish the company with a minor's release (on form provided for this purpose) properly executed by his parent or guardian.

(6) Apprentices are subject to the shop rules and the general rules and regulations of the company, and are liable to discipline or discharge for violation of these rules.

(7) Apprentices will be paid for the actual number of hours worked each day; overtime to be paid for in accordance with the rules of the company; each day's work will be regarded as but one day in the apprenticeship record. (Apprentices will not be required to work overtime during the first three years of their term of service, except in special emergencies.)

(8) Apprentices who are working with mechanics on piecework jobs will be paid their regular hourly rates; mechanics thus assisted by apprentices on piecework jobs will be paid only the proper proportion of the piecework rate.

(9) Apprentices will be given the best opportunity to learn their trades and to become good mechanics.

(10) Apprentices will be expected to comply with such regulations as to attendance at night schools or other classes as the company may see fit to prescribe.

The general training and supervision of the apprentice outside of the shop and the desirability of a regular compensation for apprentice services and the rate of payment were urged as follows:

While your committee is confining itself explicitly herein to suggestions for a course of shop training, and not for the general education and moral training of the boy, there should be a certain general education as part of the shop training. Your committee strongly recommends a careful record being kept of each apprentice by a system of merit and demerit marks, allowing a maximum number of marks for each week or month. The record should be carefully and regularly kept in a book, and while the essential thing to be considered in the marks is the application of the apprentice and the excellence of his work, his general behavior should be considered, and the maximum number of marks should not be attainable by an apprentice who in any way is not well behaved, quite apart from his actual work done. Your committee desires to insist strongly upon the desirability of such a record.

An important question, which perhaps does not bear directly upon the training of the apprentice as a mechanic, but may have a good deal to do with his shaping as a man, is the matter of payment. There should be a definite scale of payment per hour for the first year, and that scale should be increased yearly. This scale must perhaps necessarily vary in different parts of the country. Uniformity, however, all over the country is desirable. Your committee would suggest as an equitable scale of pay 50 cts. a day for a ten-hour day, that is, 50 cts. a day for the first year and an increase of 25 cts. a day for each year thereafter. For an eight-hour day, 40 cts. a day at the start and 20 cts. increase yearly.

In conclusion the report recommended: that a standing committee on this subject be appointed, and that that committee be empowered to enter into correspondence with the management of railway companies, with a view to securing the proper treatment of apprentices and the acquiescence of the managements in the appointment of a necessary foreman and other matters, and that the committee also be given power in behalf of the association to negotiate definitely with universities or institutions of learning for the establishment of courses in specified districts, without waiting for the approval of next year's convention.

The last recommendation of the report aroused quite an active discusion, many of the members seeming to fear that in carrying it out the Association would be entering a field which it should not. The standing committee was finally authorized by vote with the distinct understanding that it should not compromise the Association in any way, and in fact with but little power to do anything but report to the next convention.

Metal for Cylinders, Valves and Valve Seats.

The question upon which this committee was appointed to report was: What kind of metal, hard, medium or soft, should be used in locomotive cylinder valve seats and valves; should the metal for valve seats and valves be the same or different? The committee held that the subject involved two considerations; (1) the strength of the material in a casting of the form of a locomotive cylinder; (2) the question of friction between lubricated surfaces. After presenting some of the general considerations governing these two points and stating methods and practice on a number of railways the committee recommended: (1) As a rule cylinders should be made of metal as hard as is consistent with machining requirements; (2) Shrinkage should receive close attention in making cylinders; (3) Members having the facilities should make systematic tests of hardness, shrinkage and strength of the metal used in cylinders and supplement them with chemical analyses; (4) Valves should be of cast iron.

A particularly interesting discussion was presented on this report by Mr. S. M. Vauclain (Baldwin Locomotive Works) in which he outlined the experiments and investigations which had been conducted by these well-known locomotive builders to determine the best character of iron for cylinders and valves. Somewhat abbreviated, Mr. Vauclain's remarks were as follows:

During the last two years we have been thoroughly investigating the character of the iron best adapted for use in cylinders and valves. After a carefully conducted and elaborate series of tests we settled upon the composition having the desired physical properties, and then calculated the cupola charges, disregarding entirely the brands or furnace grading of the irons, using our tests of the ore together with our knowledge of the losses that occur in melting as a basis of such calculations. The first step was to adopt some systematic record. We therefore entered the exact weight of the various kinds of iron, of coke and of flux that composed each charge on one side of the folio page. A standard test piece was taken from each tap, and the results of all tests entered on the opposite page. The tensile and subsequently the transverse tests with the chemical analysis were made regularly, shrinkage, chill and abrasion tests were made when it was deemed necessary. The tensile tests are cast in 1¼-in. cylinders and turned down to ⅞-in. taper section, and pulled in ball and socket shackles. The transverse tests are 1 in. square, tested in rough section.

It was early shown that in order to have castings of uniform quality considerable care must be used in charging the cupola, the irons composing the different charges must be thoroughly mixed, otherwise the small pieces of metal or that having a low melting point will be first melted down, giving castings of entirely different characteristics from the same charge. Over 10,000 tests have been made in all, and while all the results have not as yet been systematically tabulated with a view of establishing a relation between the physical and chemical properties of cast iron, we have gone far enough to remove all doubt of the existence of such a relation. There is also quite a definite relation between the strength of the iron and the wearing properties, but it is wrong to assume that the harder the iron the better the wearing qualities. The shrinkage of an iron is generally assumed to increase with the strength, but this is not true with a properly mixed iron, for we can regularly run irons up to 32,000 or 33,000 lbs. without increasing the shrinkage. On the other hand, the iron that gave us the greatest trouble from shrinkage was an extremely soft low tensile iron, 18,000 lbs. Our experience indicates that with proper composition an iron can have as high a tensile as 35,000 lbs. without danger of the cylinder cracking. The tendency to crack bears a more definite relation to the shrinkage than to the hardness.

Regarding the tests in detail, perhaps the most interesting are the abrasion or wearing tests. The specimen, a cylinder ⅝-in. diameter 1 in. high was turned from the broken tension tests, these were carefully weighed and the loss in weight noted after test. The test consisted in weighting the cylinder and abrading it by rubbing in contact with a hardened steel die. The results of a number of samples are graphically shown in diagram 1. It will be noted that up to 28,000 lbs. the wear decreases rapidly as the tensile increases. The best wearing material ranges in tensile strength from 28,000 to 32,000 lbs. per sq. in., but within these limits a given increase in strength did not show a proportionate increase in wearing qualities.

Regarding the chemical properties there are perhaps more misconceptions concerning sulphur than any other element. Any defects that develop are invariably attributed to sulphur. We, however, found that an iron is undesirable for use in cylinders unless it contains a minimum of .07%, and that it really exerts beneficial results up to .12%. The difficulties of getting a perfect casting from such a complicated mold as a locomotive cylinder increases when the sulphur runs above .15%, and the tendency to crack is also greater. A large part of the sulphur in cast iron is derived from the fuel, so that to keep this element within limits it is really more essential to watch the coke and working of the cupola than the pig iron. Generally speaking, sulphur increases the tensile strength by increasing the solubility of the graphite in the iron, though our data are not yet in shape to give quantitative results. Silicon, as is well known, acts as a softener, and we aim to secure a silicon of from 1.3% to 1.7% in our cylinder mixtures. Phosphorus and manganese both act as hardeners, and if present in too large amounts make the iron brittle. They both tend to give the finished casting a good, clean, light color, and when below 0.8% can do no harm. Our experience has been chiefly with low manganese irons, for during the process of melting the principal part of the manganese seemed to become oxidized so that the casting rarely contained more than 4%.

We therefore aim to have our cylinder mixtures conform to the following specification:

Tensile strength, 27,000 to 33,000 lbs.; combined carbon, about .06%; manganese, about .35%; phosphorus, .6 to .9%; sulphur, .07 to .12%.

Our pig irons being so mixed in charging that the mixture would supply that element which would otherwise be lacking.

To show the uniformity of the product, if proper care is observed, the following tests are taken from our records. In no two instances was the same kind of iron used in making up the mixtures:

Tensile, lbs. per sq. in.	Percentage of— Carbon.	Manganese.	Phosphorus.	Sulphur.	Silicon.
35,960	.52	.35	.63	.11	1.47
30,900	.51	.34	.57	.10	1.62
30,130	.51	.33	.75	.10	1.49
28,310	.50	.35	.83	.07	1.50
31,390	.54	.36	.74	.08	1.41
31,800	.60	.32	.65	.10	1.44
32,700	.62	.35	.59	.12	1.52
30,530	.50	.32	.49	.12	1.35
31,110	.63	.34	.59	.12	1.41

Tests 8 and 9 contain more than 50 % of an iron which when used alone gave exceedingly brittle, soft and dirty cylinders, but when judiciously mixed with other irons gave exceptionally good results. Incidents such as these, and this is not the only case of its kind, lead us to believe that there is little in the claims that certain brands of pig iron possess special characteristics. There is no doubt but that the same qualities can be had by properly blending different grades to get the desired iron for the work at hand. The mixture of charcoal and ordinary pig iron give exceptionally good wearing irons, but cylinders cast with such mixtures are quite apt to crack. The same can be said of cold blast iron.

Ratios of Grate Area, Heating Area and Cylinder Volume.

This report gave evidence of careful preparation and contained a number of valuable tables and diagrams which will receive attention at another time. Its conclusions, briefly summarized, were as follows:

For simple passenger and freight locomotives the ratio of grate area in square feet to total cylinder volume in cubic feet should not be less than 4 for large anthracite coal, 9 for small anthracite coal and 3 for bituminous coal. The ratio of heating surface in square feet to total cylinder volume in cubic feet should not be less than 180 for large anthracite coal, 200 for small anthracite coal and 200 for bituminous coal. The ratio of heating surface to grate area should not be less than 40 for large anthracite coal, 20 for small anthracite coal and 60 for bituminous coal. The ratio of fire-box heating surface to total heating surface should be about 10%. The ratio of tube length to outside diameter should not be less than 70, and may be as much as 90. The ratio of

steam port length in inches to cylinder area in square inches for passenger locomotives should preferably be about 10%. This can be accomplished either by using piston valves or Allen valves. In the latter case the Allen valve has been considered as doubling the length of port. In freight locomotives which normally make fewer revolutions, the ratio may be from 5% to 8%. Finally your committee wishes to state that its deductions and calculations must always be used with discretion, and in every case the locomotive should be designed for the work it has to do, not merely accepting the formulas for all varieties of service without modification.

There was practically no discussion on this report, nor upon the succeeding report upon Boiler Jackets, the reading of which closed the proceedings of the second session of the convention, except for some topical discussion which will receive attention further on.

Painted and Planished Iron for Boiler Jackets.

The duty of this committee was to investigate the relative economy of planished and painted iron for boiler jackets, keeping in mind good appearance, first cost and cost of maintenance, and the conclusion it arrived at was that it is more economical to use sheet iron or steel painted than to use planished iron, thus confirming the pretty general opinion of railway men. The committee found that the general practice was to paint sheet iron jackets from twice a year to once in 2½ years, but the general recommendation was to renew the paint at least every six months. As to the color and cost of the paint to be used opinions varied. Black paint was most used but the cost ran from 033 ct. to 7.7 cts. per sq. ft., though usually it was about from 0.6 ct. to 2 cts. per sq. ft. It was the almost universal opinion that it was necessary to paint the inside of the jacket iron to prevent interior rust and corrosion, and the common practice was to use some of the common metallic paints for this purpose. It appeared that boiler laggings of asbestos cement, or other substances containing corrosive materials caused more rust than wood lagging if moisture got to them, but that the sap and acid of wood lagging were also a prolific cause of corrosion. The life of planished iron jackets over wooden lagging seemed to be about ten years on an average, but according to the replies it varied from two to twelve years. Excluding the cost of material the average cost of planished iron jackets was 4.06 cts. per sq. ft.; of sheet iron jackets, 4.08 cts. per sq. ft., and, of sheet steel jackets, 4.2 cts. per sq. ft. The average cost of material was, planished iron, 10.21 cts.; sheet iron, 3.64 cts., and sheet steel, 3.61 cts. per sq. ft.

It was the prevailing opinion that painted iron jackets were less seriously affected by acid laden moisture drippings from roundhouse roofs than was planished iorn.

Third Session.

Only two special committee reports were presented at this session, and after some discussion the convention proceeded to the election of officers and the usual routine business preceding final adjournment.

Piecework in Locomotive Shops.

This committee was appointed to report upon the advisability of adopting the piecework system in locomotive shops, and especially to investigate its advantages as a system for repair work as well as for new work. To ascertain the opinions of railway companies on this question the committee issued a circular of inquiry to a large number and in its report these questions and the answers received were presented at some length.

Altogether 41 railways replied to the circular, of which 24 reported that they had not tried the piecework system, 9 reported that they had adopted it, and 7 that they had introduced it to some extent. At the same time 26 railways reported that they considered it advantageous to adopt the system, and six stated that they had tried it with unsatisfactory results. In regard to the suitability of the system to repair work, 17 railways stated that they considered it perfectly applicable to such work, but all acknowledged that it was a complicated problem to adjust the prices on such work. A number of questions regarding the methods of adjusting the price usually employed brought out a great variety of answers. To the final question, as to the effect of the piecework system upon the men themselves, the summary of the answers received is as follows:

The effect on the men themselves relative to their training and general utility has been one of narrowing their capacity, as while we train them to become experts in one line of work, their interest and that of the company is to keep them in that one line, and their whole object is to reach the greatest proficiency in that one character of work, and while this has led to a greater sharpening of the wits to get up appliances and methods for such work, and where they work together to incite them to exact greater effort on the part of each other, still, this has the effect of narrowing their capacity, and unless a specific method of training is prescribed for our apprentices, it is doubtful if they will fully learn the trade and become proficient all-round mechanics.

In conclusion the committee says regarding the system:

From the foregoing, and from the fact that the value of any employee is, in direct proportion to the amount and quality of the output resulting from his efforts, it is, in the opinion of your committee, the most just and equitable method of employing men, as by this means the man who is skilled and industrious reaps the benefit of all the energy and brains expended, and is not put upon a level with one of inferior capacity, or the time server, while both he and his employer receive just what was agreed upon, and if there is a spirit of justice in the setting of prices, there will be no hardship on either side, and these prices should be based upon the average, both as to men and conditions.

A quite extended discussion followed this report, the general tenor of which was that the piecework system of employing men in railway shops was advantageous in every respect to the railway companies and would be received favorably by the men themselves if it was applied in a just and equitable manner.

Steam, Air and Electric Motors.

The main question upon which this committee was appointed to report was the following: In a locomotive repair shop what class of work can be best performed by air motors, and what is the relative convenience and economy of air motors, electric motors and steam motors for such work? The committee sent out a number of inquiries, asking the opinions and experience of railway companies, and in its report presented these questions and their answers in some detail. The concluding remarks of the report which bore definitely upon the question under investigation were, somewhat abbreviated, as follows:

The following are some of the items compressed air is universally used for in connection with suitable appliances, with an average of from 25 to 50% economy over the former practice: Tapping out stay-bolt holes; screwing in stay bolts; reaming and drilling holes; chipping and caulking; removing tires; beading tubes; air hoists, vertical and horizontal; and for all purposes including foundry and roundhouse elevators; jacks for raising cars, trucks and locomotives; telescope jacks used in connection with drop pit for dropping drivers; press for forming tinware of every description; presses for general machine shop use and pressing in bushings, driving brasses, etc.; large boiler punches; shears, erected and used outside of shop for the purpose of shearing off test coupons; punching holes that would otherwise necessarily have to be drilled, as the ordinary power punch and shears are not of sufficient gap for the large sheets now going into general use; tank riveters; stay-bolt nippers and pullers; light stationary air hammers in blacksmith shop, made out of Westinghouse brake cylinders, to be used at tool dresser's fire or where general light work is done; shears at scrap pile for cutting up old bolts to standard lengths, and hammer for straightening; shear for light sheet-iron work, made from Westinghouse cylinder at minimum cost; feed for upright nut-tapping machine, allowing operator to handle six taps; also drilling safety holes in stay bolts before being screwed in firebox; machine for centering all bolts before turning; Westinghouse cylinders to operate vises without screw; by the operation of air, apply couplings to remove clamps from air hose; also the same appliances for operating a knife to cut off old hose from nipples; sandpapering machine; small Pelton wheel for operating small emery wheels; for sharpening tools in convenient places through the shop; blast for blacksmith forges; Westinghouse engine operating large transfer table; applied to mixing paint in large quantities by putting a pipe in the bottom of a barrel; used in all kinds of motors for boring cylinders and facing valves; grinding steam pipes; driving any special machine when line shaft is not running; cleaning out flues; in connection with gasoline for removing tire; cleaning cushions and carpets in and out of cars; blowing out cylinders before applying packing; testing staybolts; also to move engines to other locations; for different purposes, such as painting, bending pipe, operating letter press, rolling flues, swedging flues, testing brakes, painting cars, sanding roofs, bridges and depots, and several other purposes.

Your committee is decidedly under the impression that both air and electricity are an advantage over steam for portable motors, and also there are conditions existing where the elastic power is preferable for large permanent motors via line shaft, for driving large tools, and where a convenient operation of an overhead crane is desired. Leaving the latter out of the question, however, where a line shaft can be conveniently operated with a well-designed stationary plant, your committee is under the impression that the latter is the more economical. For small portable tools the air motors are no doubt more convenient, if not as economical. As the committee is unable to gather any definite information based upon practical results that would assist us to establish that fact, but considering the danger of electricity which exists to some extent at least, and then considering the convenience of air in and around the shop and the fact that any ordinary mechanic can repair, look after and handle air motors, the relative difference would have to be considerable to make the former preferable; however, the power transmitting capabilities of each in combination with their other individual and peculiar lines of usefulness opens for them a distinct and separate field in which neither can be substituted for the other; therefore, it is well to anticipate the possible requirements for other than the transmission of power before coming to a final conclusion.

In the discussion which followed little was brought out which added much to the information given in the report. Mr. Geo. Gibbs, C., M. & St. P., considered that it was a mistake to apply air or steam to rotary motion for individual tools or processes, except in isolated cases, and under exceptional conditions. For this kind of work electricity was the preferable power. At the same time, for hoists, jacks, and similar tools where a lifting or thrusting motion was required pneumatic, hydraulic or steam power were more convenient than electricity.

Topical Questions.

According to a special provision of the by-laws the noon hour of each session was devoted to the discussion of topics suggested by the members, and a number of these discussions were quite brisk and valuable. Such of the subjects as seem of more general interest are presented here with the important features of their discussion.

The Best Design and Material for Piston Rods.

This subject was introduced by Mr. G. W. Henderson (Norf. & Wn.), who called attention to the possibilities of using hollow steel tubes for piston rods. He stated that the saving in weight was nearly 50% over the solid rod, and that the cost was so little greater that it cut practically no figure. Mr. Robt. Quayle (Chic. & N. W.) stated that he had been using nickel steel for piston rods and although these rods had not been long enough in service to enable exact data to be given regarding their efficiency, yet so far they had given excellent satisfaction.

Compound vs. Simple Locomotives.

The discussion on this subject was quite long, and, as it is a subject which has been very frequently handled during the past five or six years, only its general tenor and a few of the more important figures given will be presented. Hardly a member who took the floor on the subject did not admit the economy of the compound over the simple locomotive for freight service, although a number called a timely warning against assuming too quickly that every economy shown by running compound engines in comparison with simple engines was due alone to the compound principle of using steam. Among the performance records presented, the following were the most concise and explicit:

Mr. W. S. Morris (C. & O.)—The comparative performances of one compound and ten simple engines, exactly alike except for the compound principle, for four consecutive years show the following results: The average mileage of the simple engines was 139,606 miles and of the compound engines 165,187 miles; the cost of repairs was 15% more for the compound than for the simple; the compound ran 19.2 miles more per ton of coal than the simple, and 30.9 miles more per pint of oil for lubrication. The total cost of oil and waste, fuel and repairs for the compound engine for the four years was 8.4% less than for the simple engines.

Mr. Geo. Gibbs (C., M. & St. P.)—We have compiled some figures from service tests on our road with four cylinder compounds. During the last two years I have not exercised any supervision personally over the tests of compound locomotives. In fact, I desire to let the engines tell their own story. I had a record made of 11 Vauclain compound engines and 11 simple engines of the same build and exactly similar, except that the compounds carry 200 lbs. pressure as against 180 of the simples; but one of the simples does carry 200 lbs., and for the three years she has been in service we have not discovered any extra economy in the additional 20 lbs. The record is on a ton-mile basis, the tonnage given for every train and engine on a two-division road. Each end of the division the engines are equally distributed between compounds and simples, five of each. The records for each month are given in detail in pounds of coal per hundred tons hauled one mile. The record for the compound engine is on an average 12.11 lbs.; for the simple engine 14.59 lbs. or an economy of the compound over the simple of 20.3 lbs. The variations in economy of the compound over the simple run from 25 lbs. down to 17.5 lbs. There is another conclusion to be drawn from this; at the beginning of the record the engines were new, and the record extends to the first of February this year. The economy in the first month was the same as in the last, which is a good showing for the piston valve. My impression is that it is very seldom that we find a simple engine with a better economy than any one of the compounds; in other words, all the compounds stand above any one of the simple engines. One of these compounds we have had in service for about five years. I have not figured on the matter of repairs, oils, etc. Unless the simple gear is thrown in at starting, they are not so powerful; but after getting to a speed of eight or ten miles an hour they are smarter engines than the simple. The starting gear can be thrown in, of course, at six miles an hour and under. The engineers themselves have found out very quickly that above that speed there is a difference.

Piston Valves for Simple Locomotives.

The discussion on this subject was opened by Mr. Forsyth (C., B. & Q.), who said:

The subject of piston valve has probably been referred to me because we happen to have two simple engines with piston valves, while the majority of engines in this country equipped with piston valves are compound. I do not know why there should be any distinction made in the service. The slight experience we have had with these two engines has shown one or two points of interest. It is rather difficult to set piston valves; one of these valves is in the saddle directly under the steam chest and quite long, and it is difficult to fix the port lines and their relation to the valve correctly. We had to have them set over quite a number of times before we got them right. We found that the ports in the bushing were not truly at right angle with the axis of the bushing, and were slightly angular, so that the admission line, measured from below, was perhaps 1-16 in. different from what it was above, and it is important in making bushings for piston valves to see that the port lines do not vary. We found, also, that the packing ring is really the cut-off point. We trimmed off the edge of the metal outside the packing ring and made it as smooth as possible to give the steam more chance to enter the port. In doing that we obtained an increase of mean pressure under the same conditions of 15 to 20%. When made of large diameter, and similar to the designs of Mr. Vauclain in his engines, piston valves will wear very little and give good service; and, strange to say, the wearing of the packing ring is not so much on the circumference as on the sides, and that points to the importance of making the depth of the ring as great as possible. I believe with pressures of 180 lbs. and above they will be found to have advantages over the ordinary solid piston valve. Incidental to this is the freedom of the use of the reverse lever. With an engine under full steam at 200 lbs., it is possible to move the reverse lever easily, and thus change the cut-offs at will. I believe that a portion of the wastefulness of some engines is due to the fact that the valves work so hard that it is difficult to change the reverse lever.

Election of Officers.

The closing work of the third session was the election of the officers of the Association for the ensuing year. The officers elected were: President, Pulaski Leeds (L. & N.); First Vice-President, Robert Quayle (C. & N. W.); Second Vice-President, J. H. McConnell (Union Pac.); Third Vice-President, W. S. Morris (Chesa. & O.); Treasurer, J. N. Barr (C., M. & St. Paul.).